North Fork Palouse River Dissolved Oxygen and pH Total Maximum Daily Load

Water Quality Improvement Report and Implementation Plan

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Cover photo: North Fork Palouse River near the intersection of Hwy 272 and N. River Road, in Palouse, Washington. Photo credit: Department of Ecology.

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North Fork Palouse River Dissolved Oxygen and pH Total Maximum Daily Load

Water Quality Improvement Report and Implementation Plan

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Abstract

Water quality data indicated the North Fork of the Palouse River was impaired by low dissolved oxygen and high pH. These conditions do not support fish and insects that live in the water. Therefore, as required by the Clean Water Act, Ecology developed this total maximum daily load report and implementation plan to explain the conditions causing the impairment and the steps needed to restore the river to conditions that meet state water quality standards to support aquatic life use. The primary cause of dissolved oxygen and pH problems in this system is excess dissolved inorganic nitrogen. This report includes nitrogen permit limits for several entities in the watershed. It also outlines activities that will reduce nitrogen delivery from various land uses and conditions within the watershed.

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Executive Summary

Introduction

Ecology developed this water quality improvement report and implementation plan because the North Fork Palouse River has insufficient dissolved oxygen (DO) and high pH that do not protect fish and other aquatic life. Data gathered by Ecology's ambient monitoring program resulted in segments of the North Fork Palouse River being listed on the 2008 impaired waters list [303(d) list] for DO and pH as well as on prior 303(d) lists beginning in 1996. In 2007, Ecology initiated a study in this watershed to address these 303(d) listings (Carroll, 2007).

This document contains the findings of the study, along with recommendations for restoring water quality, as well as an implementation plan that lays out the roles and responsibilities for reducing and eliminating the pollutants causing the low DO and high pH problems.

Why did we develop a total maximum daily load (TMDL)?

The federal Clean Water Act (CWA) requires that a total maximum daily load (TMDL) be developed for each of the water bodies on the 303(d) list. The 303(d) list is a list of water bodies, which the CWA requires states to prepare, that do not meet state water quality standards. The TMDL study identifies pollution problems in the watershed, and then specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, agencies, and the community develops a plan that describes actions to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities.

Watershed description

The Palouse River flows through Water Resource Inventory Area (WRIA) 34 in southeastern Washington. The upper part of the watershed extends into western Idaho beyond Potlatch.

This TMDL addresses DO and pH in the portion of the Palouse River within Washington upstream of the South Fork Palouse River confluence at Colfax, locally known as the North Fork Palouse River. (This is not to be confused with another stream, also called the North Fork Palouse River, which is a small tributary above Laird Park in Idaho.) The study focuses on the North Fork Palouse River and associated tributaries near their confluence with the mainstem (Figure ES-1).

The North Fork Palouse River is required to meet water quality criteria for DO and pH to support fish and other aquatic life. The amount of oxygen dissolved in the water and the pH of that water are vital to the health and sustainability of fish populations. When oxygen levels fall too low some fish and certain insects (that are food for fish) which live in streams cannot survive.

Similarly, pH can affect the biologic and chemical balance within natural systems and can result in toxic or lethal conditions for aquatic life.

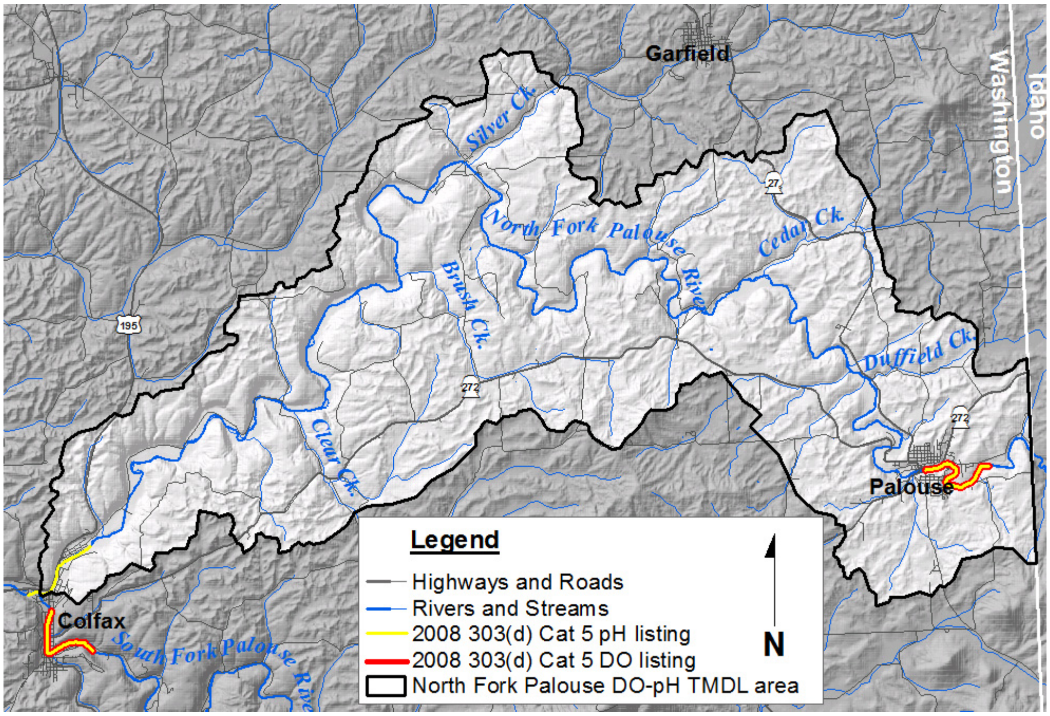

Figure ES- 1. North Fork Palouse River TMDL Study Area.

The goal of this water quality improvement report and implementation plan is to bring the river into compliance with water quality standards for DO and pH to support healthy aquatic life. More detail about the water quality criteria is described within the body of this document.

What needs to be done in this watershed?

The TMDL study found that the periphyton (bottom algae), which drive DO and pH in the North Fork Palouse River, are extremely sensitive to inputs of dissolved inorganic nitrogen (DIN). DIN is the combination of nitrate, nitrite, and ammonia. Background levels of DIN in the river are near zero, and even small DIN inputs can have large impacts on DO and pH. This means that to restore natural DO and pH levels in the watershed, DIN needs to be reduced to near-zero levels during May-October. The primary form of nitrogen in this system is nitrate; therefore, this TMDL and Implementation Plan describes activities needed to reduce DIN with an emphasis on reducing nitrate.

The most obvious source of DIN with the largest water quality impact in the North Fork Palouse River is the city of Palouse's Wastewater Treatment Plant (WWTP). However, nonpoint sources throughout the watershed can have important localized water quality effects where nitrogen enters the river system.

The city of Palouse's WWTP has a permit to discharge to the North Fork Palouse River. To address DIN from the treatment plant, the permit will need to include wasteload allocations for DIN and biological oxygen demand (BOD). Two other entities are covered under permits which address stormwater discharges statewide. They are the Washington State Department of Transportation (WSDOT) and Empire Disposal in Colfax. While WSDOT is not currently considered a permittee within this TMDL's boundary, after this TMDL is approved implementation activities listed within it will be incorporated into the WSDOT permit when it is renewed in 2019. Therefore, WSDOT is referred to as a permittee within this TMDL and provided with wasteload allocations. All wasteload allocations are summarized in Table ES-1.

Table ES - 1. Wasteload allocations for NPDES permitted dischargers.

Water-body Name	Parameter of Concern	Time Period Restrictions	Permittee Name	Wasteload Allocation
Palouse River (North Fork)	Dissolved inorganic nitrogen (DIN)	May-October	Palouse Wastewater Treatment Plant	DIN WLA is dependent on stream flow. See explanation within *Load and Wasteload Allocation* section of this report.
Palouse River (North Fork)	Biochemcal Oxygen Demand (BOD)		Palouse Wastewater Treatment Plant	6.5 kg/day
Palouse River (North Fork) via City of Colfax storm sewers	DIN		Empire Disposal Industrial Stormwater	DIN and BOD WLAs are part of bubble allocations shared with other sources throughout the system. See Load and Wasteload Allocation section of this report.
	BOD			
Palouse River (North Fork) and tributaries	DIN		WSDOT[1] Municipal Stormwater	DIN and BOD WLAs are part of bubble allocations shared with other sources throughout the system. See *Load and Wasteload Allocation* section of this report.
	BOD			

1 – WSDOT will become a permittee within this TMDL boundary once the TMDL is approved and incorporated into their NPDES municipal stormwater permit in 2019.

Water in the North Fork Palouse River flows downstream very slowly during the summer low-flow period. This has an important effect on the geographic extent of DO and pH impacts. In many rivers, nutrient inputs from multiple sources add to each other to create a cumulative impact. However, in the North Fork Palouse River, any DIN input creates a localized impact that occurs in the reach immediately downstream of the input. Downstream of that reach, DO and pH levels recover until the next DIN source. Because of this, load and wasteload allocations in this TMDL are assigned using a "segmented" approach that accounts for this pattern. This approach is detailed in the *Load and Wasteload Allocations* section of this report.

To address the nonpoint and stormwater sources of DIN throughout the watershed the following implementation activities are necessary:

- Investigation into a potential source of ammonia and/or nitrate observed downstream of the beginning of the floodworks in Colfax. If a source is found, it must be corrected.
- Prevention of non-stormwater discharges from stormwater outfalls.

- Elimination of effluent from septic systems that are failing near surface water or potentially contaminating groundwater.
- Reduction of livestock impacts to the stream corridor.
- Prevention of runoff from biosolid application sites.
- Prevention of soil erosion and fertilizer nutrient release to streams or groundwater from agricultural and residential land.
- Reduction of human activities that increase stream bank erosion.
- Designing and planning land uses so as to not result in runoff to streams.
- Adhering to state forest practices rules for all forest practices, including timber harvest and road construction and maintenance.

Stream temperature is also important to achieving water quality standards for DO and pH. Therefore, restoration of full system potential shade on the North Fork of the Palouse River, in accordance with the Palouse River Temperature TMDL (Snouwaert and Stuart, 2013), is also required.

Why this matters

The levels of DO and the pH of the water are vital to the health of the fish, animals, and insects that live there. When a river is outside healthy conditions, fishery populations decline, which diminishes the resource for recreational and subsistence fishing. Additionally, the pollutant that causes low DO levels and wide pH swings in the North Fork Palouse River is nitrogen, a nutrient that supports plant growth. When this nutrient is in excess, algae and other plants grow at elevated rates in the water leading to unsightly algal blooms and surface scum. These conditions lessen the aesthetic value of the river.

In July and August of 2014, several algal blooms were observed in the North Fork Palouse River, especially in the section just upstream of Colfax (Figure ES-2). These blooms resulted in a bright green color that could be seen from the concrete floodworks upstream past Glenwood Road (Whitman County Gazette, 2014a). Others reported it was observed as far upstream as the City of Palouse. Analysis of this algae bloom indicated the presence of blue-green algae (also known as cyanobacteria). Blue-green algae can produce toxins that can sicken or kill animals and people that drink from or recreate in the water. Livestock and pets are at greatest risk as people typically avoid the water when they see these conditions.

Following the algal blooms, a large fish kill occurred in the North Fork Palouse River on August 13-14, 2014. An estimated 2000 fish died due to low DO in the water (Whitman County Gazette, 2014b). The DO may have plummeted because the excess algae consumed the oxygen overnight while not producing more through photosynthesis.

Events such as the algal blooms and fish kills emphasize the importance of addressing excess nutrients, so the river can support its beneficial uses of fishing, recreation, livestock watering, and aesthetics.

Figure ES-2. The confluence of the North Fork Palouse River and the South Fork Palouse River during the July 2014 algal bloom.

North Fork water with algal bloom (right side) mixing with water from the South Fork where there was not an algal bloom (left side).

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What is a Total Maximum Daily Load (TMDL)

A TMDL is a numerical value representing the highest pollutant load a surface water body can receive and still meet water quality standards. Pollutant loading over the TMDL level needs to be reduced or eliminated to achieve clean water.

Federal Clean Water Act requirements

The Clean Water Act (CWA) established a process to identify and clean up polluted waters. The CWA requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of (1) designated uses for protection, such as cold water biota and drinking water supply, and (2) criteria, usually numeric criteria, to achieve those uses.

The Water Quality Assessment and the 303(d) List

Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the CWA 303(d) list. In Washington State, this list is part of the Water Quality Assessment (WQA) process.

To develop the WQA, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data in this WQA are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The WQA divides water bodies into five categories. Those not meeting standards are given a Category 5 designation, which collectively becomes the 303(d) list].

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data or insufficient data available.

Category 4 – Polluted waters that do not require a TMDL because they:

- 4a. – Have an approved TMDL project being implemented.
- 4b. – Have a pollution control program in place that should solve the problem.
- 4c. – Are impaired by a non-pollutant such as low water flow, dams, or culverts.

Category 5 – Polluted waters that require a TMDL – the 303(d) list.

Further information is available at Ecology's Water Quality Assessment website (www.ecy.wa.gov/programs/wq/303d/).

The CWA requires that a TMDL be developed for each of the water bodies on the 303(d) list.

TMDL process overview

Ecology uses the 303(d) list to prioritize and initiate TMDL studies across the state. The TMDL study identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, tribes, agencies, and the community, develops a plan to control and reduce pollution sources as well as a monitoring plan to assess effectiveness of the water quality improvement activities. This comprises the *water quality improvement report* (WQIR) *and implementation plan* (IP). The IP section identifies specific tasks, responsible parties, and timelines for reducing or eliminating pollution sources and achieving clean water.

After the public comment period Ecology addresses the comments as appropriate. Then, Ecology submits the WQIR/IP to the U.S. Environmental Protection Agency (EPA) for approval.

Who should participate in this TMDL process?

Sources contributing to DO and pH impairments within the study area (Figure 1) come from both nonpoint and point sources. Nonpoint sources are the diffuse and diverse sources that come from everyday activities in the watershed. Examples of nonpoint sources include residential lawn care, failing septic systems, agricultural runoff, and many others. Point sources include discharges to a stream that are allowed through a permit. Examples include wastewater treatment discharges and some municipal stormwater. Nonpoint source pollutant load targets have been set in this TMDL. Because nonpoint sources are diffuse, all upstream watershed areas have potential to affect downstream water quality. Therefore, all potential nonpoint sources in the watershed must use the appropriate best management practices to reduce impacts to water quality. Similarly, all point source dischargers in the watershed must also comply with the TMDL.

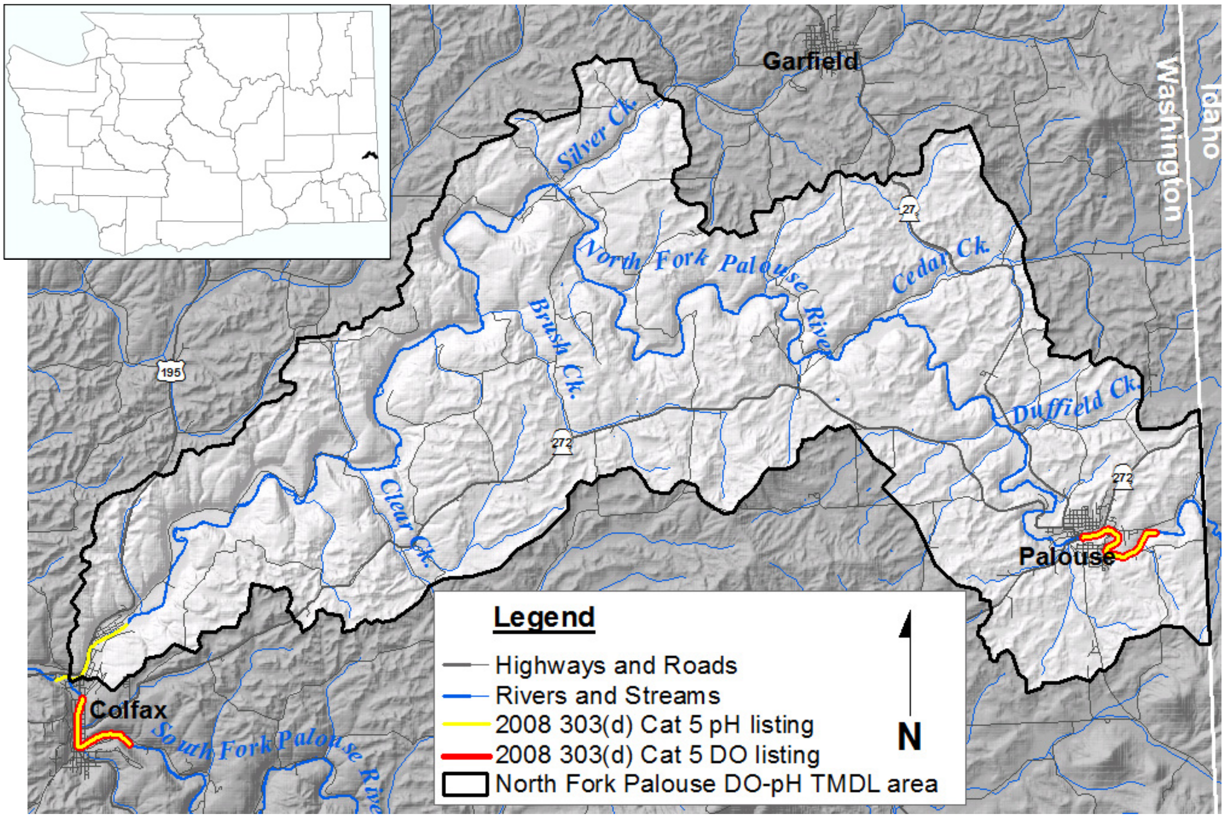

Figure 1. Location of the North Fork Palouse DO-pH TMDL area in eastern Washington.

Elements the Clean Water Act requires in a TMDL

Loading capacity, allocations, seasonal variation, margin of safety, and reserve capacity

A water body's *loading capacity* is the amount of a given pollutant that a water body can receive and still meet water quality standards. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

The portion of the receiving water's loading capacity assigned to a particular source is a *wasteload* or *load* allocation. If the pollutant comes from a discrete (point) source subject to a National Pollutant Discharge Elimination System (NPDES) permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from diffuse (nonpoint) sources not subject to an NPDES permit, such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*.

The TMDL must also consider *seasonal variations* and include a *margin of safety* that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A *reserve capacity* for future pollutant sources is sometimes included as well.

Therefore, a TMDL is the sum of the wasteload and load allocations, any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity.

Why Ecology Conducted a TMDL Study in this Watershed

Background

Ecology conducted a TMDL study in this watershed because the Palouse River has insufficient DO and high pH that do not protect fish and other aquatic life. Data gathered by Ecology's ambient monitoring program were the basis for placing segments of the Palouse River on the 2008 303(d) list for DO and pH as well as on prior 303(d) lists beginning in 1996. In 2007, Ecology initiated a TMDL study in this watershed to address these 303(d) listings (Carroll, 2007). This report presents the findings of that study and the steps needed to increase DO and reduce pH to meet water quality standards.

The Idaho Department of Environmental Quality (IDEQ) developed a TMDL for the upper tributaries in the Idaho portion of the Palouse River watershed (Henderson, 2005), but the Idaho TMDL did not include the mainstem Palouse River. Ecology previously completed a TMDL for chlorinated pesticides and PCBs in the entire Washington portion of the watershed (Johnson et al., 2007). Ecology also completed TMDLs for Fecal Coliform on the portion of the Palouse River upstream of the South Fork Palouse River confluence at Colfax, locally referred to as the North Fork (Snouwaert and Ahmed, 2005), the South Fork Palouse River (Carroll and Snouwaert, 2009), and the mainstem Palouse River downstream of the South Fork confluence (Tarbutton et al., 2010). Ecology also completed a TMDL for temperature on the entire Washington portion of the Palouse River including the section referred to as the North Fork, but not including the South Fork (Snouwaert and Stuart 2013).

The South Fork Palouse River was the subject of data collection during 2006 and 2007 for a related DO-pH TMDL study (Carroll and Mathieu, 2006), which will be presented in a separate report. The South Fork Palouse River meets the mainstem Palouse River immediately downstream of Colfax at river mile 89.6. Although data were collected in 2007 to address DO and pH listings in the section of the Palouse River downstream of the North Fork/South Fork confluence (Carroll, 2007), a TMDL for this lower section of the river cannot be evaluated at this time. The primary impact to this lower part of the river results from nutrient inputs from the South Fork which obscure the effects of other point and nonpoint sources to the Palouse River in and downstream of Colfax. These impacts will need to be addressed by the South Fork Palouse DO-pH TMDL before developing a TMDL for the lower mainstem section.

TMDL area

The Palouse River flows through WRIA 34 in southeastern Washington. The upper part of the watershed extends into western Idaho beyond Potlatch.

This TMDL addresses DO and pH in the portion of the Palouse River upstream of the South Fork Palouse River confluence at Colfax, locally known as the North Fork Palouse River. (This is not to be confused with another stream, also called the North Fork Palouse River, which is a small tributary above Laird Park in Idaho.) The study focuses on the North Fork Palouse River and associated tributaries near their confluence with the mainstem (Figure 1).

Impairments addressed by this TMDL

This TMDL addresses the Category 5 2012 303(d) listings for DO and pH in the portion of the Palouse River located upstream of the South Fork Palouse River confluence at Colfax, locally referred to as the North Fork Palouse River. (Table 1, Figure 1). DO and pH impairments result in the stream not fully supporting the beneficial use of aquatic life which diminishes the stream's value as a fishery and for recreation. Additionally, nutrients, the pollutants leading to the impairment, also cause excessive growth of algae and plants, reducing the beneficial uses of aesthetics and recreation. In the summer of 2014, the river experienced a blue-green algae bloom. While testing indicated no toxicity present during this particular bloom, blue-green algae can produce toxins that affect people and animals.

Table 1. Study area water bodies on the 2012 303(d) list for dissolved oxygen and pH.

Water Body	Parameter	Listing ID	Township	Range	Section
Palouse River	Dissolved oxygen	11133	16N	46E	6
Palouse River	pH	42553	16N	43E	11
Palouse River	pH	8112	16N	46E	6

These 2012 303(d)-listed segments led to the development of a TMDL study in this watershed. During the research and data-gathering process for this study, additional water-body segments were found that do not meet state water quality standards (Table 2). Enough data was collected to add each of these segments to the 303(d) list according to Ecology's listing policy (WQP Policy 1-11). Prior to publication of this TMDL Ecology released the draft 2014 303(d) list for public comment. For reference the listing identification (ID) numbers are indicated in Table 2. These segments are also addressed by this TMDL.

Table 2. Additional study area segments that do not meet water quality standards for dissolved oxygen and pH which are addressed by this TMDL.

Water Body	Parameter	Draft 2014
Palouse River	Dissolved oxygen	77904
Palouse River	Dissolved oxygen	77903
Palouse River	Dissolved oxygen	77902
Palouse River	Dissolved oxygen	77901
Palouse River	Dissolved oxygen	77900
Palouse River	Dissolved oxygen	77899
Palouse River	Dissolved oxygen	77898
Palouse River	Dissolved oxygen	42522
Palouse River	Dissolved oxygen	8110
Palouse River	Dissolved oxygen	8108
Palouse River	pH	70788
Palouse River	pH	70787
Palouse River	pH	70786
Palouse River	pH	70785
Palouse River	pH	70784
Palouse River	pH	70783
Palouse River	pH	70782
Palouse River	pH	70781
Palouse River	pH	8113
Cedar Creek	Dissolved oxygen	77905
Clear Creek	Dissolved oxygen	77908
Clear Creek	pH	70794
Silver Creek	Dissolved oxygen	77907
Silver Creek	Dissolved oxygen	77906
Silver Creek	pH	70792

Note: Township, Section, and Range information is not provided due to the 2014 303(d) list's switch to the use of the National Hydrography Dataset (NHD) for stream segmentation.

Because this report is limited to the study area in Figure 1, it does not address other segments in the watershed on the 303(d) list or impaired for DO and pH (Table 3).

Table 3. Palouse watershed water bodies on the 2012 303(d) list or impaired for dissolved oxygen and pH which are not included in this TMDL.

Water Body	Parameter	Listing ID	Township	Range	Section	Reason not included
Palouse River	Dissolved oxygen	48167	15N	38E	21	Palouse River and tributaries downstream of SF Palouse confluence not included in TMDL – see explanation in previous text
Palouse River	Dissolved oxygen	48165	15N	37E	32	
Palouse River	pH	42582	15N	38E	21	
Palouse River	pH	6732	15N	37E	26	
Palouse River	pH	51468	15N	37E	32	
Palouse River	pH	16922	14N	37E	31	
Rebel Flat Creek	Dissolved oxygen	8150	17N	40E	29	
Pleasant Valley Creek	pH	42803	19N	41E	34	
Pine Creek	Dissolved oxygen	11127	20N	43E	10	
Silver Creek	Dissolved oxygen	Not listed yet	17N	44E	11	Outside study area
Paradise Creek	Dissolved oxygen	8144	14N	46E	5	Will be treated separately in SF Palouse DO-pH TMDL
SF Palouse River	Dissolved oxygen	8126	14N	45E	8	
SF Palouse River	Dissolved oxygen	8142	14N	45E	5	
SF Palouse River	Dissolved oxygen	11137	14N	45E	6	
SF Palouse River	Dissolved oxygen	8015	16N	43E	14	
SF Palouse River	pH	6729	16N	43E	14	
Missouri Flat Creek	Dissolved oxygen	8013	14N	45E	5	

SF: South Fork

Water Quality Standards and Numeric Targets

Dissolved oxygen

Aquatic organisms are very sensitive to reductions in the level of DO in the water. The health of fish and other aquatic species depends on maintaining an adequate supply of oxygen dissolved in the water. Oxygen levels affect growth rates, swimming ability, susceptibility to disease, and the relative ability to endure other environmental stressors and pollutants. While direct mortality due to inadequate oxygen can occur, Washington State designed the criteria to maintain conditions that support healthy populations of fish and other aquatic life.

Oxygen levels can fluctuate over the day and night in response to changes in climatic conditions as well as the respiratory requirements of aquatic plants and algae. Since the health of aquatic species is tied predominantly to the pattern of daily minimum oxygen concentrations, the criterion is based on the lowest 1-day minimum oxygen concentrations that occur in a water body.

In the Washington State water quality standards, freshwater aquatic life use categories are described using key species (salmonid versus warm-water species) and life-stage conditions (spawning versus rearing). Minimum concentrations of DO are used as criteria to protect different categories of aquatic communities, some of which are specified for individual rivers, lakes, and streams.

The Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC (Ecology, 2006) designate the following use to the portion of the Palouse River locally referred to as the North Fork and to all tributaries:

Salmonid Spawning, Rearing, and Migration – This use protects salmon and trout spawning that only occurs outside of the summer season (September 16 – June 14). Other characteristic aquatic life uses include rearing and migration by salmonids.

The DO criterion for salmonid spawning, rearing, and migration states [WAC 173-201A-200(1)(d)]:

> *The one-day minimum dissolved oxygen concentration shall not fall below 8.0 mg/L more than once every ten years on average. When DO is lower than the criterion (or are within 0.2 mg/L of the criterion) due to natural conditions, then cumulative human-caused activities will not decrease the dissolved oxygen more than 0.2 mg/L.*

The criterion of 8.0 mg/L is used to maintain conditions where a water body is naturally capable of providing full support for its designated aquatic life uses. The standards recognize, however, that not all waters are naturally capable of staying above the fully protective DO criterion. When a water body is naturally lower in oxygen than the criterion, the state provides an additional allowance for further depression of oxygen conditions due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.2 mg/l decrease below that naturally lower (inferior) oxygen condition.

pH

The pH of natural waters is a measure of acid-base equilibrium achieved by the various dissolved compounds, salts, and gases. It is an important factor in the chemical and biological systems of natural waters. pH both directly and indirectly affects the ability of waters to have healthy populations of fish and other aquatic species. Changes in pH affect the degree of dissociation of weak acids or bases. This effect is important because the toxicity of many compounds is affected by the degree of dissociation. While some compounds (e.g., cyanide) increase in toxicity at lower pH, others (e.g., ammonia) increase in toxicity at higher pH.

While there is no definite pH range within which aquatic life is unharmed and outside which it is damaged, there is a gradual deterioration as the pH values are further removed from the normal range. However, at the extremes of pH lethal conditions can develop. For example, extremely low pH values (<5.0) may liberate sufficient carbon dioxide from bicarbonate in the water to be directly lethal to fish.

The state established pH criteria in the Washington State water quality standards primarily to protect aquatic life. The criteria also serve to protect waters as a source for domestic water supply. Water supplies with either extreme pH or that experience significant changes of pH even within otherwise acceptable ranges are more difficult and costly to treat for domestic water purposes. pH also directly affects the longevity of water collection and treatment systems, and low pH waters may cause compounds of human health concern to be released from the metal pipes of the distribution system.

The pH criterion for salmonid spawning, rearing, and migration states [WAC 173-201A-200(1)(d)]:

> *pH must be kept within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.5 units.*

These criteria are used to maintain conditions where a water body is naturally capable of providing full support for its designated aquatic life uses. The standards recognize, however, that not all waters are naturally capable of staying within the fully protective pH criteria. When a water body is naturally lower or higher than the criteria, this natural pH level becomes the local criteria. Only when the pH is within the criteria range can the combined effects of all human activities cause not more than a 0.5 units change. When the natural pH level is outside the criteria range, the standards only allow a *de minimis* change (the change that is considered the limitation of accurate measurement) of 0.1 unit for human activities.

Watershed Description

The Palouse River basin is located primarily in Whitman County, Washington, with its headwaters located in the Hoodoo Mountains in the St. Joe National Forest in Latah County, Idaho (Henderson, 2005; Figure 1). From the Idaho border, the reach of the Palouse River locally referred to as the North Fork Palouse River flows roughly 33 river miles to the South Fork Palouse River confluence. There the river flows about 85 miles to Palouse Falls. Palouse Falls drops over a 198 foot high basalt shelf about six river miles upstream of the Palouse River's mouth at the Snake River.

The watershed area of the Palouse River upstream of the South Fork Palouse River is approximately 495 mi^2 (1,282 km^2; 316,799 acres) and contributes around 83 percent of the mean annual flow of the Palouse River at Colfax (Ahmed, 2004). The portion of the Palouse River upstream of the South Fork Palouse River confluence is often referred to locally as the North Fork Palouse River, and will be referred to as such for the rest of this document. This is not to be confused with another stream, also called the North Fork Palouse River, which is a small tributary to the headwaters portion of the river above Laird Park in Idaho.

Figure 2 shows the North Fork Palouse River where it flows through the community of Elberton, approximately halfway between Palouse and Colfax.

Figure 2. The North Fork Palouse River at Elberton.

Photo credit Tighe Stuart.

The dryland agriculture that dominates land use in the North Fork Palouse watershed is visible in the upland areas of this photo. Steptoe Butte is in the background.

Climate

The Palouse River watershed in Washington mostly has a semi-arid climate. The North Fork Palouse River lies in a less arid part of the watershed, with annual precipitation ranging from around 20 inches near Colfax to 50 inches in the eastern headwater mountains of Idaho, where the mean annual precipitation increases roughly seven inches with every 1,000 foot increase in elevation. Precipitation peaks during winter and falls primarily as snow especially in the mountains (Gilmore, 2004). Summer precipitation is typically less than an inch per month, with July being the driest month. Summer precipitation typically falls during intermittent thunderstorms. Summer daily maximum air temperatures can range from the mid-1970s (ºF) to the mid-1990s (around 21ºC to 35ºC) and occasionally over 100ºF (37.8ºC).

Geology

Around 110 million years ago, geologic activity forced giant granite slabs upward, creating distinct landscape features in southeast Washington. Eventually, regional volcanic activity began. Fissures opened as the Palouse River basin received intermittent lava flows 10-30 million years ago, which filled the valleys with Columbia River basin basalts. Receding ice age glaciers, coupled with an arid climate, produced fine-grained sediment that was carried by prevailing winds. This wind-blown sediment, called loess, deposited on the basalt, forming large dunes known as the Palouse formation. The immense Missoula floods that created the channeled scablands generally did not affect the North Fork Palouse portion of the watershed, with floodwaters running further to the west.

Vegetation

Historically, the North Fork Palouse River watershed supported a variety of vegetation types. For example, two types of perennial grass were dominant, Idaho fescue (*Festuca idahoensis*) and blue bunch wheatgrass (*Pseudoregneria spicata*). Shrubs included snowberry (*Symphoricarpos* spp.), black hawthorn (*Crataegus douglasii*), and rose (*Rosa* spp.) that grew often on the north aspect of the loess hills. Riparian areas commonly supported quaking aspen (*Populus tremuloides*) and cow parsnip (*Heracleum lanatum*) (an herb) among other mentioned species herein.

Forest communities grew in the higher elevations. Such species included ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), and western larch (*Larix occidentalis*), depending on aspect and available water. The forest understory included ocean spray (*Holodiscus discolor*), ninebark (*Physocarpus malvaceus*), serviceberry (*Amelanchier alnifolia*), snowberry, and wild rose.

Currently, most of the Palouse Prairie has been converted to cropland (Gilmore, 2004). Riparian corridors are now dominated by reed canary grass (*Phalaris arundinacea*), a widespread exotic invasive species.

Hydrology

The North Fork Palouse River drains an area of 495 mi^2, most of which is in Idaho. Tributaries to the North Fork Palouse River in Washington include Duffield Creek, Cedar Creek, Silver Creek, Brush Creek, and Clear Creek.

The United States Geological Survey (USGS) currently operates one streamflow gage on the North Fork Palouse River. USGS streamflow gage #13345000 is located near Potlatch, ID at river mile 132.2 downstream of US Highway 95. This gage station near Potlatch captures 317 square miles of the Palouse watershed. It has recorded from 1914 to 1919, and 1966 to present.

Figure 3 depicts the box-plots of monthly flows for the North Fork Palouse River recorded at Potlatch. Peak flows typically occur from January through March, and baseflows from August through September. Streamflows in the North Fork Palouse River vary dramatically between seasons, with median March flows about 60 times higher than median September flows.

Although the hydrology of other parts of the Palouse watershed is influenced by groundwater inputs and springs, the influence of groundwater on the portion of the North Fork Palouse in Washington appears to be minimal. Streamflow balances based on measurements taken at low flow do not indicate any increases in flow that are attributable to groundwater inputs.

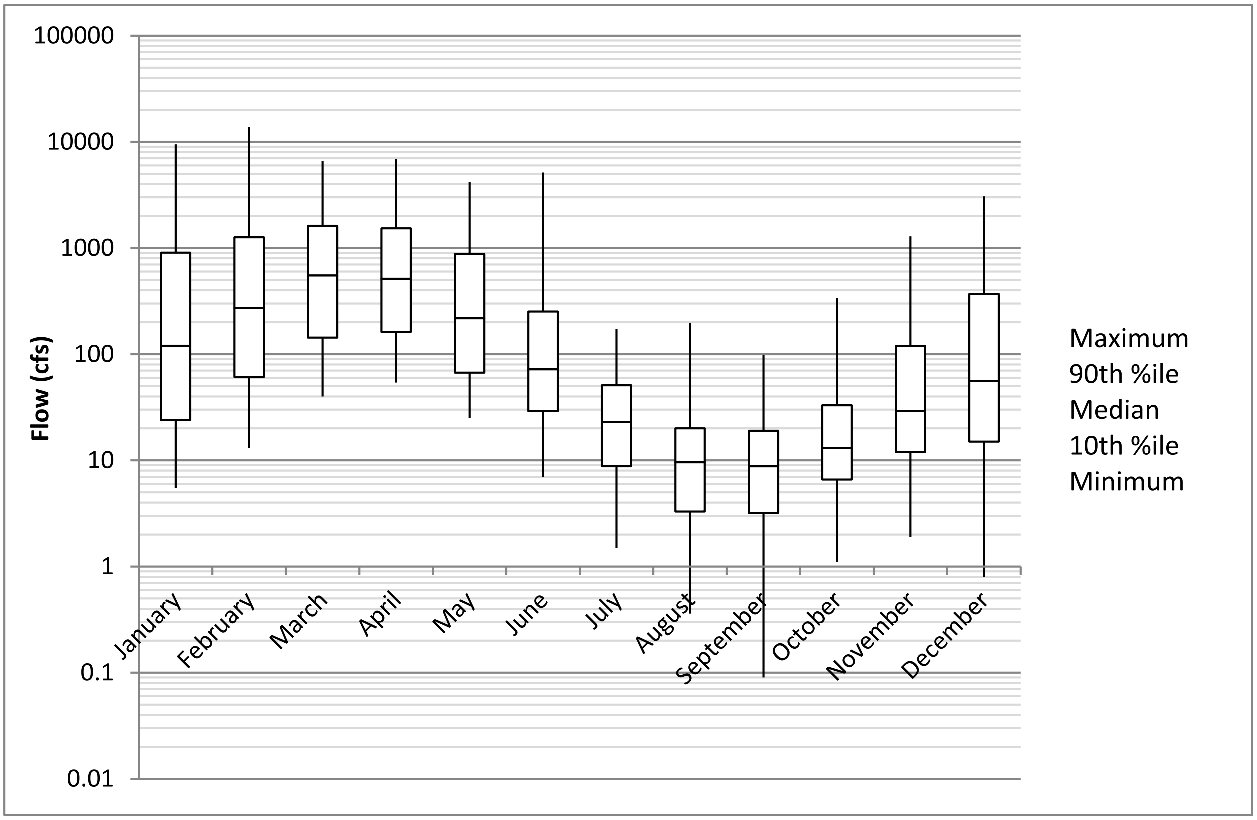

Figure 3. USGS stream-gage monthly flow statistics between 1914 and 2012 for the Palouse River near Potlatch, ID.

Flows are plotted on a log-scale

Land-use patterns

Land use within the study area is dominated by dryland agriculture. Colfax (population about 3,000) is the largest town within the North Fork Palouse watershed. The next largest town is Palouse (population about 1,000). Garfield (population about 600) is located in the watershed, but is outside the area of this TMDL. Agricultural use of water from the Palouse River is limited to adjacent land. To date, about 20 water rights exist that draw water from the North Fork Palouse River. These surface water withdrawals are typically used for irrigation and stock.

Sources of pollution

The primary pollutants that can result in impairments to DO and pH are nutrients, such as nitrogen and phosphorus, and biochemical oxygen demand. Excessive nutrients can result in excessive growth of algae, which exchanges dissolved gasses, including oxygen and carbon dioxide, with the surrounding water. If natural reaeration processes cannot keep up with algal gas exchange, then DO and pH levels will "swing" throughout the course of the day. During daylight hours, algal photosynthesis outpaces respiration, driving up DO levels. At the same time, the photosynthesis depletes dissolved carbon dioxide, raising the pH of the water. At night, photosynthesis ceases, and respiration dominates, depleting DO and at the same time increasing dissolved carbon dioxide, which reduces pH.

Biochemical oxygen demand (BOD) is the term used to describe the depletion of DO from the water by the oxidation of organic substances. BOD can be either (1) carbonaceous, resulting from the oxidation of carbon-containing compounds such as sugars, or (2) nitrogenous, resulting from the oxidation of nitrogen-containing compounds such as ammonia. The addition of these organic substances to a water body can result in reduced DO content in the water downstream of the pollution source.

Point Sources

Table 4 lists the facilities in the TMDL area that are regulated under National Pollutant Discharge Elimination System (NPDES) permits.

Table 4. Point source permits that discharge to, or are adjacent to, the North Fork Palouse River.

Facility	Facility Type	Permit #	Discharges to	Discharge Frequency
Palouse WWTP	Municipal IP	WA0044806C	Palouse River	Year-round, continuous
Washington State Dept. of Transportation	Municipal Stormwater GP	WAR043000A	Palouse River and various tributaries	Occasional
Empire Disposal, Inc.	Industrial Stormwater GP	WAR010082	Palouse River via City of Colfax municipal storm system	Occasional
Seubert Excavators Portable Crusher 1	Sand and Gravel GP	WAG500055	Does not discharge	

IP: Individual Permit. GP: General Permit.

Nonpoint Sources

Nonpoint sources and practices are dispersed and not readily controlled by discharge permits. BOD and nutrients from nonpoint sources are transported to the creeks by direct and indirect means. Several types of nonpoint sources could be present in the study area including:

Runoff sources

- Soil erosion from agricultural fields and residential areas can carry nutrients to streams, especially if fertilizers are applied in excess of what the plants can utilize.
- Manure that is spread over fields during certain times of the year can enter streams via surface runoff or fluctuating water levels.
- Livestock can increase nutrient delivery where manure is deposited in the riparian area. Fluctuating water levels and surface runoff can wash nutrients into the water, which can be further exacerbated by constant trampling which loosens soil, delivering both the soil and absorbed nutrients to the water.
- Pet waste concentrated in public parks or private residences can be a source of contamination, particularly in urban areas.

Non-runoff sources

- Some residences may have wastewater piped directly to waterways or may have malfunctioning on-site septic systems where effluent seeps to nearby waterways.
- Livestock with direct access to water can deposit nutrients in their waste directly to the stream.
- Tile drains, installed primarily in agricultural areas to drain shallow groundwater, may contribute nutrients.
- Unnatural bank erosion due to land use activities, channelization, stream straightening, and riparian vegetation removal, deposits soils into the streams. These soils typically carry nutrients.
- Groundwater discharge to tributaries of the North Fork Palouse River also affects DO levels and nutrient concentrations. In this basin, background BOD or nutrient concentrations may be elevated due to upland practices such as agricultural field fertilizing and wastewater discharge to groundwater from on-site septic systems. No significant discharges of groundwater occur to the North Fork Palouse River during summer low flow conditions however.

Wildlife and Background Sources

A wide variety of perching birds, upland game birds, raptors, and waterfowl are found within the Palouse River watershed. Birds, elk, deer, moose, beaver, muskrat, and other wildlife in rural areas are potential sources of nutrients. Open fields and riparian areas lacking vegetation are attractive feeding and roosting grounds for some birds whose presence can increase BOD and nutrients in runoff.

Usually these sources are dispersed and do not affect DO and pH in streams significantly enough to violate Washington State criteria. Sometimes birds and animals are locally concentrated.

Background concentrations of nutrients can also occur naturally from geologic sources. In the case of the North Fork Palouse River, background concentrations of inorganic nitrogen, the limiting nutrient, tend to be close to zero. Furthermore, geologic sources of calcium carbonate (often referred to as "alkalinity") occur in similar concentrations in the North Fork Palouse River as in other rivers in Washington, and at lower concentrations than many rivers in Eastern Washington.

Other Contributing Factors

The North Fork Palouse River has a number of characteristics that may exacerbate the tendency of nutrients to contribute to DO and pH impairments:

- The water tends to be very warm during summer, with temperatures as high as 33°C having been recorded (Snouwaert and Stuart, 2013). High temperatures increase the rate of chemical and biological processes, including periphyton and macrophyte growth and respiration. Additionally, high temperatures reduce the capacity of water to hold DO, leading to overall lower concentrations.
- The river is very wide and poorly shaded, meaning that most points on the river are in full sunlight for most of the day, providing full light for periphyton and macrophyte growth.
- The river is relatively shallow and clear during the summer, meaning that not much light gets blocked before reaching the streambed, where periphyton grows.
- The substrate is mostly rock, providing an excellent growing surface for periphyton that encompasses most of the streambed.
- The river experiences low flows and quiescent conditions during the summer, with slow velocities and gentle riffles. These conditions limit the "flushing capacity" of the river, and also limit natural reaeration processes.

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Goals and Objectives

Project goals

The goal of this water quality improvement report and implementation plan is to address DO and pH problems in the North Fork Palouse River in order to improve water quality and restore beneficial uses. More specifically, the goal is for the North Fork Palouse River to meet Washington State DO and pH water quality standards.

Study objectives

To support these project goals, a TMDL field monitoring and modeling analysis study was undertaken. A Quality Assurance Project Plan (QAPP) was developed for the TMDL study (Carroll, 2007). Data were collected in both the North Fork Palouse and the mainstem Palouse from the South Fork Palouse confluence to the mouth. However, the scope of the TMDL was revised to include only the North Fork Palouse River after it became apparent that a significant portion of the mainstem below Colfax is primarily influenced by nutrient load from the South Fork Palouse River. Data collected in parts of the watershed other than the North Fork Palouse River are not presented in this report. The objectives of the study are:

- Characterize summertime DO and pH conditions in the North Fork Palouse River and at the mouths of major tributaries.
- Characterize nutrients, periphyton and macrophyte biomass, organic carbon, and related variables that play a role in determining DO and pH conditions.
- Develop a predictive computer model of DO and pH in the Palouse River using QUAL2Kw, focusing on conditions occurring during critical low flows and high temperatures.
- Evaluate loading capacities for nutrients and/or BOD needed to meet water quality standards for DO and pH.
- Establish load and wasteload allocations within the stream's loading capacity.

Implementation objectives

The objectives of the TMDL's implementation plan are to:

- Identify sources of nutrients contributing to the DO and pH impairments.
- Reduce and eliminate sources of nutrients.
- Measure progress toward obtaining water quality standards.

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TMDL Analysis

Analytical framework

The QUAL2Kw water quality model (Pelletier and Chapra, 2008; Chapra 1997) was used to simulate the effects of nutrients on periphyton growth, and in turn, DO and pH, in the North Fork Palouse River. QUAL2Kw is a one-dimensional numerical model capable of simulating a variety of conservative and non-conservative water quality parameters.

There are several important concepts for modeling the effect of primary productivity in running waters. Among the most important are:

1. Usually, only one nutrient can limit algal growth at a time. The limiting nutrient will be the least available relative to its demand. This principle is known as Liebig's law of the minimum (Chapra, 1997).
2. For river modeling, it is important to limit the growth rate to control algal biomass yield. The growth rate is limited by the concentration of the most limiting nutrient (i.e. the supply rate of the limiting nutrient),[1] and by temperature. In some situations other factors limit growth instead of nutrients, such as space available for attachment or light availability.
3. It is appropriate to use the dissolved-fraction concentration of the limiting nutrient, such as soluble reactive phosphorus (SRP) and dissolved inorganic nitrogen (DIN), as the basis for modeling periphyton growth. This is because the nutrient must be in a readily-available form for biological uptake and growth to occur during solute transport (Welch and Jacoby, 2004).
4. Total phosphorus and nitrogen are important to model since the particulate and organic fractions can be transformed into the dissolved fractions through various instream and hyporheic processes.

Unlike previous versions of QUAL2Kw, the version used to model the North Fork Palouse River (QUAL2Kw 6.0) is capable of simulating a river continuously throughout the course of a season. This is useful because it allows one model scenario to simulate conditions during different parts of the critical season, and to be calibrated to multiple datasets collected at different times. QUAL2Kw was used to model the section of the North Fork Palouse River between the Washington/Idaho state line (34PAL124.3) and Glenwood (34PAL98.3). Detailed documentation of the model segmentation, inputs, calibration, and goodness-of-fit is provided in Appendix C. QUAL2Kw requires the following types of data:

- Nutrient (nitrogen, phosphorus, and carbon) concentration data
- Diel or continuous DO, pH, and temperature data
- Streamflow data
- Algae/aquatic plant biomass data
- Continuous meteorology data
- Groundwater nutrient and flow data

[1] QUAL2Kw has the ability to limit algal growth based on any of three different principles: 1.) Liebig's law of the minimum, as described above; 2.) multiplicative; and 3.) harmonic mean. The multiplicative and harmonic mean options allow for nutrient co-limitation, but each have particular drawbacks. The Liebig minimum option is most commonly used, and is used in this study.

Ultimately, the calibrated QUAL2Kw model was used to estimate the assimilative load capacity for DIN and BOD in the Palouse River, which are the basis for the load and wasteload allocations assigned in this TMDL.

Methods

To provide the data needed by the QUAL2Kw model, a field data collection effort was conducted during summer low-flow and high temperature conditions in 2007 and 2012. Methods for data collection, compilation, and assessment were governed by the data requirements for the temperature model and are described in the QAPP (Carroll, 2007) and addendum (Carroll, 2012). Table 5 lists the sampling locations where data were collected and the types of data that were collected at each location.[2] Figure 4 shows a map of the sampling locations.

Table 5. Sampling locations used during the North Fork Palouse River DO-pH TMDL study.

Location ID	Location Description	2007				2012	Latitude	Longitude
		Nutrients / Field Measurements	Periphyton/ Macrophytes	Continuous Temp	Continuous Hydrolab	Continuous Hydrolab		
34PAL124.3	Palouse River at State Line	X	X	X	X	X	46.9123	-117.0382
34PAL122.2	Palouse River nr Loop Rd.					X	46.9082	-117.0573
34PAL120.8	Palouse River at S. River Rd.					X	46.9101	-117.0686
34PAL120.3	Palouse River at Bridge St.	X	X	X	X	X	46.9090	-117.0760
34PAL120.0	Palouse River at Main St.					X	46.9087	-117.0831
34PAL118.9	Palouse River at Hwy 272	X	X	X	X	X	46.9145	-117.0853
34PAL116.8	Palouse River at Duffield Ck.					X	46.9301	-117.0915
34PAL112.4	Palouse River at Altergott Rd.	X	X	X	X	X	46.9471	-117.1455
34PAL103.9	Palouse River at Elberton	X	X	X	X		46.9818	-117.2201
34PAL98.3	Palouse River at Glenwood	X		X	X		46.9302	-117.2851
34PAL91.7	Palouse River above Colfax	X			X[3]		46.9076	-117.3381
34PAL91.5	Palouse River above SF Palouse confluence	X	X	X	X		46.8897	-117.3659
34SIL00.0	Silver Creek at mouth	X		X	X		46.9820	-117.2202
34PALWWTP	Palouse Wastewater Treatment Plant effluent	X		X	X		46.9087	-117.0830

SF: South Fork

[2] Location IDs consist of the WRIA number (34), the first three letters of the stream name ("PAL" for Palouse River), and the USGS river mile. Although the section of river treated in this TMDL is often referred to as the North Fork Palouse River and is called such in this report, it is officially a part of the Palouse River. Therefore the location IDs include "PAL" and the river miles count from the mouth of the Palouse River at Lyons Ferry.
[3] Continuous Hydrolab data was collected at 34PAL91.7 during the August synoptic survey but not during the July one.

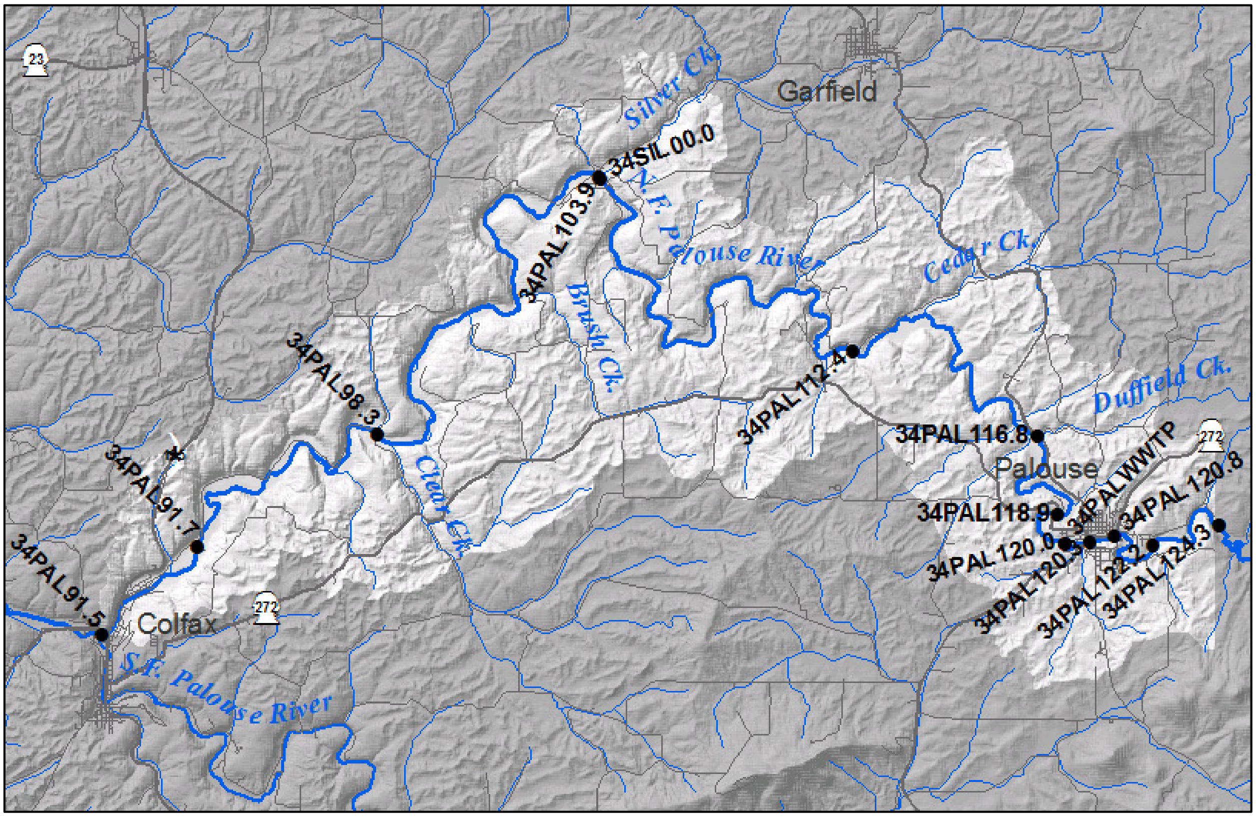


Figure 4. Sampling locations for the North Fork Palouse DO-pH TMDL study.

Nutrients

Ecology and Adams Conservation District collected water samples and measurements during two synoptic surveys, one on July 30, 2007, and the other on August 27, 2007. Table 6 lists the sample parameters collected as well as the analytical method used. All samples were analyzed by Ecology's Manchester Environmental Laboratory. For most parameters, two sets of samples were taken at each site during each synoptic, one in the morning and another in the afternoon. At Palouse WWTP, samples were collected using an ISCO® compositor, in addition to grab samples.

Table 6. Sample parameters collected.

Parameter	Method	Frequency
Chloride	EPA 300.0	2x/survey
Total Suspended Solids	SM 2540D	1x/survey
Total Non-Volatile Suspended Solids	EPA 160.4	1x/survey
Turbidity	SM 2130	1x/survey
Alkalinity	SM 2320	2x/survey
Ammonia	SM 4500-NH_3 $^{-}$H	2x/survey
Dissolved Organic Carbon	EPA 415.1	2x/survey
Nitrate/Nitrite	SM 4500-NO_3 $^{-}$I	2x/survey
Total Persulfate Nitrogen	SM 4500-NO_3 $^{-}$B	2x/survey
Total Phosphorus	EPA 200.8 modified	2x/survey
Orthophosphate	SM 4500-P G	2x/survey
Total Organic Carbon	EPA 415.1	2x/survey

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, 2005; ASTM, 1997).
EPA = EPA Method Code.

Field measurements

During the synoptic sampling surveys in 2007, field measurements of temperature, conductivity, pH, and DO were taken using a Hydrolab® multiprobe concurrent with collection of samples. In addition, at most sampling locations, another Hydrolab® multiprobe was deployed to record these same parameters continuously (at 15-minute intervals) over approximately a 24-hour period in order to capture diel fluctuations.

On September 17-19, 2012, an additional set of continuous field measurements was taken using Hydrolab® multiprobes, in order to better characterize pH and DO patterns in the vicinity of Palouse (Carroll, 2012). Multiprobe instruments were deployed for either an approximately 24-hour or approximately 48-hour period.

Water temperature– continuous dataloggers

Ecology installed a network of continuous temperature dataloggers in the Palouse River watershed (Kardouni et al, 2007). Dataloggers were located at most sampling locations along the Palouse River, at the mouth of Silver Creek, and at Palouse WWTP (Table 5). Loggers were deployed from May through October of 2007 and logged temperature at 30-minute intervals.

Streamflow data

Ecology's Stream Hydrology Unit[4] installed two continuous flow measurement stations in the study area during 2007. One was located on the North Fork Palouse River at Elberton (34PAL103.9) and the other was located on the North Fork Palouse River above the South Fork Palouse River confluence (34PAL91.5). These stations recorded stage height continuously from May to November 2007 and February to June 2008. Instantaneous flow measurements were also taken at these two continuous flow-monitoring stations at approximately monthly intervals during this time period by the Stream Hydrology Unit.

Additional flow measurements were taken approximately monthly from May through October 2007 at temperature monitoring stations (Kardouni et al, 2007). Flow measurements were also taken twice per month from June 2007 through May 2008, at 34PAL91.5 (North Fork Palouse River above SF Palouse River confluence) except for when conditions prevented wading (Mathieu et al, 2007). Flow measurements were taken concurrently with synoptic nutrient sampling at all sampling stations on July 30, 2007 and August 27, 2007.

The USGS measured flows at a gaging station just upstream from the study area: Palouse River at Potlatch, Idaho (ID 13345000). USGS has historically gaged three additional locations: Palouse River at Palouse (ID 13345300), Palouse River near Colfax (ID 13346000), and Palouse River at Colfax (ID 13346100).

Periphyton and macrophytes

Periphyton consists of a community of algae, fungi, microbes, and microscopic plants and animals that grow in shallow water habitats and attach to submerged surfaces. Periphyton productivity is often one of the most important drivers of DO and pH in shallow streams and rivers. Macrophytes are rooted aquatic plants. Macrophytes can also play a role in dissolved gas exchange and nutrient dynamics.

Periphyton and macrophyte biomass data were collected on September 4, 2007 using a modified version of USGS protocols (Porter et al., 1993). Biomass data were collected at all nutrient sampling sites except for 34PAL91.7. At each site, three representative rocks were collected from the streambed. Periphyton was scraped from the rocks into the sample container along with deionized water. The surface area from which periphyton was collected was estimated by covering the portion of the rocks from which sample was collected with aluminum foil. The surface area of the aluminum foil was then measured using a computer program.

Macrophytes (not including the roots) were collected from a representative part of the streambed. A hula hoop was placed on the streambed to delineate a sampling area, and macrophytes growing inside the hula hoop were pulled and placed in a sample bag.

Periphyton and macrophyte samples were sent to Manchester Environmental Laboratory to be analyzed for Chlorophyll a and Ash-Free Dry Weight. Laboratory results and the surface areas from which samples were collected were then used to calculate periphyton and macrophyte

[4] Now called the Freshwater Monitoring Unit

biomass estimates in terms of Chlorophyll a or Ash-Free Dry Weight per square meter of streambed.

Groundwater data

Ecology conducted a study of groundwater and surface-water interactions concurrently with the Palouse TMDL study. The methods and results of the groundwater study are presented in a separate report (Sinclair and Kardouni, 2009).

Hydraulic geometry

Stream channel width, depth, and velocity have an important influence on the response of DO and pH to instream biological processes and on the downstream transport of nutrients and other substances. Each of these was determined separately as described in the following sections.

Width

High resolution color digital orthophotos were created from aerial photos flown for Ecology on May 31 and August 31, 2006. The wetted banks were digitized at a 1:3000 scale for each of these dates, and wetted widths were calculated for each 100-meter segment using the TTools extension for ArcGIS (Ecology, 2008).

Depth

A Hydrolab® Minisonde® equipped with a depth probe was mounted snugly inside a length of PVC pipe and dragged along the bottom of the channel behind a canoe. The minisonde was attached to a Surveyor® deck unit equipped with a GPS, which recorded location coordinates and a corresponding depth measurement every 30 seconds. The canoe was navigated along the center of the channel. Depth data was collected between the state line (34PAL124.3) and Glenwood (34PAL98.3).

Velocity

A time-of-travel study using rhodamine, a fluorescent, non-toxic dye, was conducted on the North Fork Palouse River to estimate velocities. Dye studies are used to estimate travel times by measuring the time it takes for a slug of the dye to reach specific downstream locations.

A survey was conducted August 21-26, 2007. Because of the slow travel times in the Palouse River during summer low-flow conditions, the survey analyzed two representative reaches. One analyzed reach extended from Bridge Street in Palouse (34PAL120.3) to Altergott Road. (34PAL112.4). The other reach extended from Elberton (34PAL103.9) to Glenwood (34PAL98.3).

At the upper end of each reach, a slug of dye was added to the river. A Hydrolab® Datasonde® equipped with a rhodamine sensor was deployed at the lower end of each reach. The travel time of the reach was calculated as the time elapsed between the dye release and the moment when the greatest rhodamine concentration was recorded at the downstream end of the reach. The average velocity of the reach was calculated as the length of the reach divided by the travel time.

Meteorological data

Hourly air temperature, humidity, wind speed, and cloud cover data were used from the National Weather Service station at the Pullman-Moscow Regional Airport. In addition, Ecology established an Onset® temporary weather station near the study area, along the South Fork

Palouse River near Colfax. The weather stations recorded wind speed and direction, solar radiation, relative humidity, and air temperature. In addition, Ecology installed a network of data loggers to continuously monitor near-stream air temperature at the same locations where there were instream continuous temperature dataloggers, and to monitor relative humidity at two locations in the study area and one location near the study area at Colfax.

Other data sources

Ambient monitoring data

Ecology's Freshwater Monitoring Unit has been collecting samples and measurements at the Palouse River at Palouse (34A140, equivalent to 34PAL120.3 in this study) from 1992 through present (Hallock and Ehinger, 2003). Parameters monitored monthly include conductivity, dissolved oxygen (DO), pH, dissolved organic carbon, total organic carbon, fecal coliform, ammonia, nitrate-nitrite, total persulfate nitrogen, orthophosphate, total phosphorus, temperature, and total suspended solids. In addition, continuous temperature dataloggers have been deployed during the summer months since 2001.

1987 Receiving water study

In 1987, Ecology conducted a receiving water study examining the effects of Palouse Wastewater Treatment Plant on the North Fork Palouse River (Kendra, 1988). The wastewater treatment plant that was in operation at the time of this study was of a different design and had significantly different effluent characteristics than the current wastewater treatment plant, which was built in 1995. Even though the data from this survey are not representative of current conditions, they were used to calibrate the water quality model response to different sorts of nutrient conditions in the river.

The study was conducted on September 29-30, 1987. Sampling locations included three sites upstream of the treatment plant, four sites downstream, as well as grab and composite samples of treatment plant effluent. Parameters sampled and measured included macroinvertebrate taxonomy, flow, conductivity, residual chlorine, fecal coliform, enterococcus, total suspended solids, biochemical oxygen demand, chemical oxygen demand, ammonia, nitrate-nitrite, and total phosphorus. Temperature, pH, and DO were measured at dawn and dusk to approximate daily minimum and maximum values.

Data quality

The quality of all data used to develop this TMDL has been assessed to ensure that it is appropriate for its intended use. Appendix B presents the details of this data quality assessment. All data were found to be of adequate quality to the meet the objectives of this TMDL. Data quality and qualifications have been taken into account in developing results and recommendations.

Field study results

Field study findings relating to the physical environment of the river are presented first. Next, nutrient results are presented. Finally, algae, DO, and pH results are presented. Observations from the field results indicate that algae growth, DO, and pH are related to nutrient concentrations in the river.

Appendix A provides a detailed summary of data collected during the field study.

Channel geometry

Depth

Figure 5 shows the depths recorded by Hydrolab® Minisonde® dragged behind a canoe on May 21-22, 2012. An important change occurs about 1/3 the way from the state line to Colfax, near the monitoring station at Altergott Road. Upstream of this point, the river has a relatively low gradient, and is moderately deep, with long pools (Figure 6) broken by occasional riffles. Downstream from this point, the gradient becomes steeper, and the river is much shallower, dominated by long riffles and glides (Figure 7).

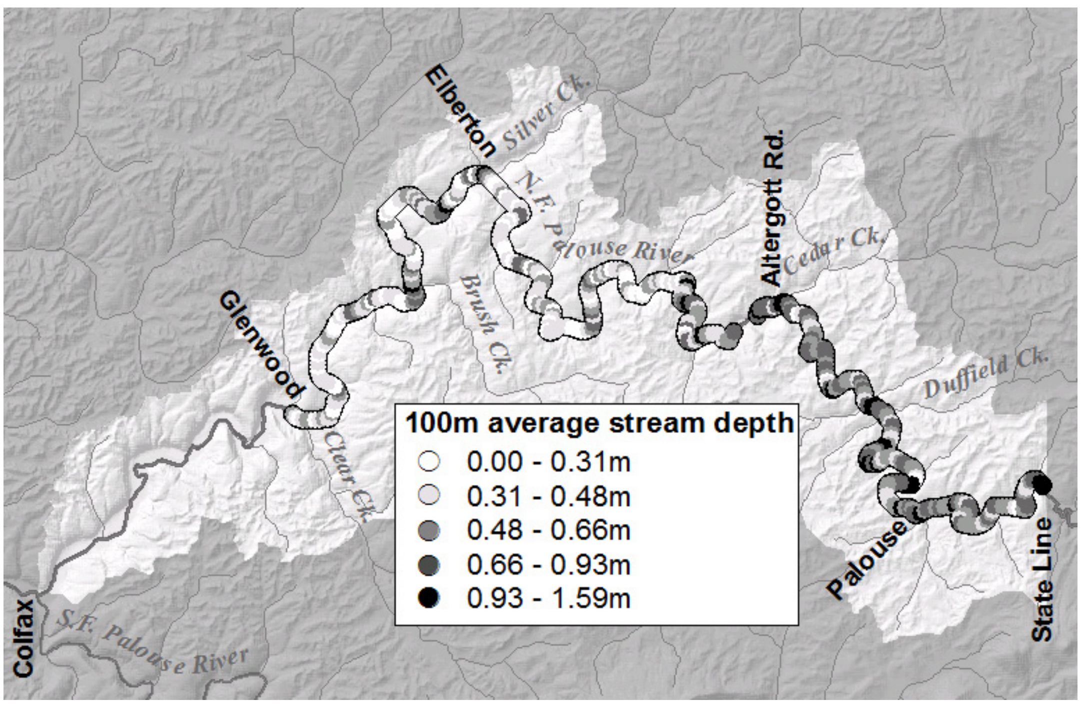


Figure 5. Map of depths of the North Fork Palouse River recorded May 21-22, 2012.

Figure 6. Deep reach near Palouse.

Figure 7. Shallow reach between Altergott Road and Elberton.

Velocity and time of travel

Table 7 presents the results of the time of travel dye study for the North Fork Palouse River. The study found that during low flow conditions, travel times on the North Fork Palouse River are very long, and velocities are very slow. This means that downstream transport of pollutants is reduced and water quality impacts from pollutants are more localized.

Table 7. Time of travel dye study results.

Dates of survey	Reach	Distance	Result		Flows recorded at USGS Potlatch gage during study
			Travel Time	Avg Velocity	
8/21-26/2007	Bridge St. in Palouse (34PAL120.3) to Altergott Rd. (34PAL112.4)	7.9 mi	118 hr 25 min (4.93 days)	0.10 ft/s	3.0 – 6.1 cfs
	Elberton (34PAL103.9) to Glenwood (34PAL98.3)	5.6 mi	114hr 57min (4.79 days)	0.07 ft/s	

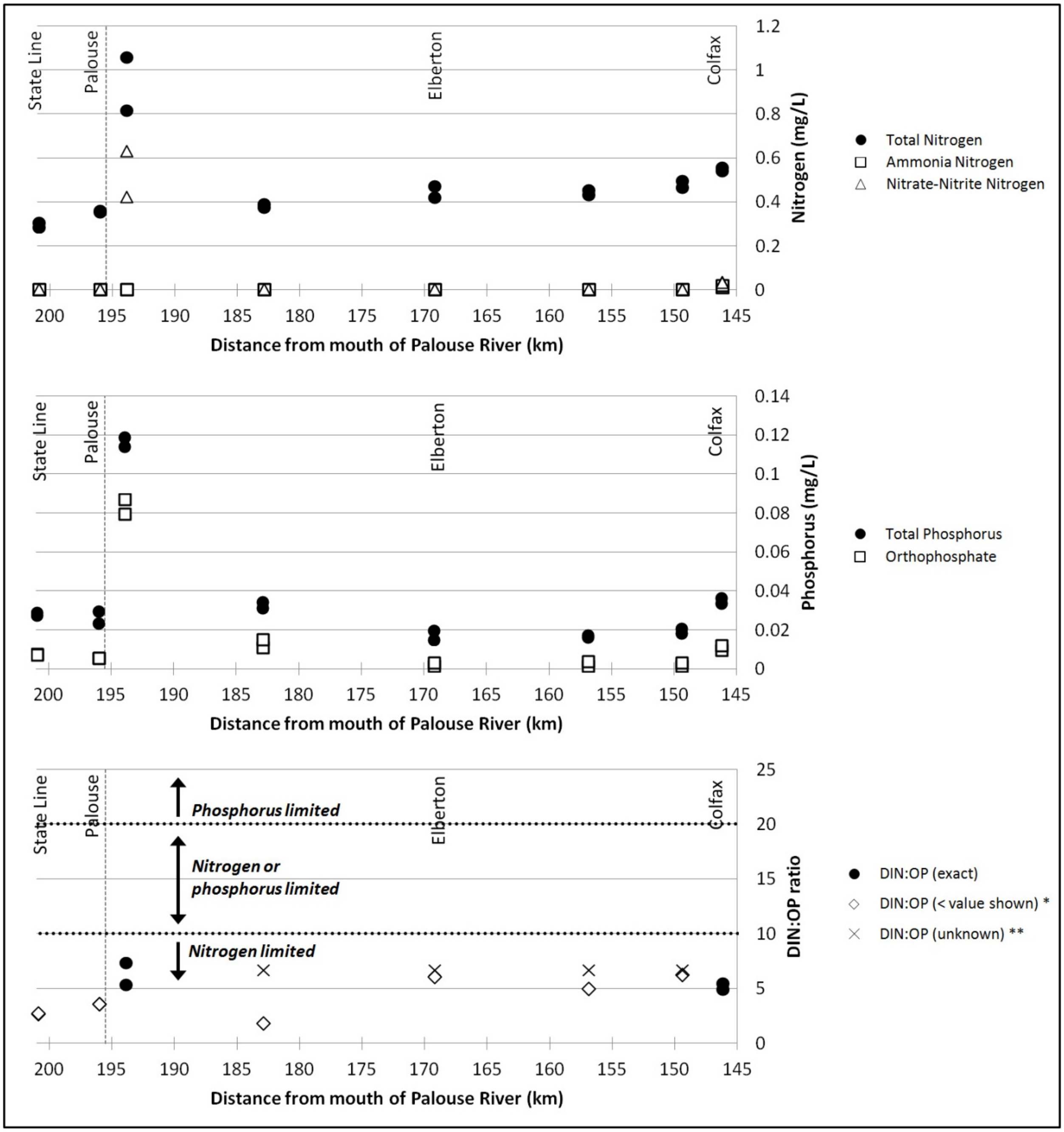
Nutrients

Figure 8 shows the nutrient concentrations measured in the North Fork Palouse River during the August 27, 2007 synoptic survey, as well as ratios of dissolved inorganic nitrogen (DIN) to orthophosphate (OP). DIN and OP, which are the inorganic forms of nutrients available to be taken up and used by algae and aquatic plants, occurred at concentrations near or below detectable levels at most locations.

An exception to this is the reach downstream of Palouse, where effluent from the Palouse WWTP provides a source of nutrients. Downstream water sampling showed that elevated levels of dissolved inorganic nitrogen discharged by the Palouse WWTP were depleted more quickly than elevated levels of discharged orthophosphate.

Somewhat elevated nutrient concentrations were also observed in the reach just above the confluence with the South Fork Palouse River, at the downstream end of the floodworks in Colfax.

Organic nitrogen and organic phosphorus, which are represented by the difference between the total and inorganic fractions (Organic N = Total N – DIN; Organic P = Total P – OP) were detected at all locations. These nutrient forms are generally not available for uptake and use by algae and aquatic plants, and were found in fairly uniform concentrations throughout the system.



* DIN is calculated as the sum of Nitrate-Nitrite and Ammonia. The less-than symbol (<) is used when Nitrate-Nitrite, Ammonia, or both is a non-detect. In this case, the actual DIN:OP ratio is unknown, but a maximum ratio can be calculated using the detection limit. Since the true value is less than the detection limit, the true ratio will be less than the calculated ratio.

** In four instances Nitrate-Nitrite, Ammonia, and Orthophosphate results were all non-detects. For these instances, the result is graphed as the ratio of the detection limit for DIN (0.02 mg/L) and OP (0.003 mg/L). The actual ratio is unknown.

Figure 8. Nitrogen and Phosphorus concentrations and ratios measured during the August 27, 2007 synoptic survey.

The vertical dashed line represents the location of the Palouse WWTP outfall. Each location was sampled twice during the day, which is why two values are typically visible.

Several observations indicate that productivity in the North Fork Palouse River is nitrogen-limited:

- The dissolved fraction ratios of nitrogen to phosphorus (DIN:OP) observed during the field studies in the North Fork Palouse indicate nitrogen limitation. Ratios of DIN (defined as ammonia plus nitrate plus nitrite) to OP of less than 10:1 indicate nitrogen limitation, ratios of over 20:1 indicate phosphorus limitation, while ratios between 10:1 and 20:1 are uncertain (Borchardt, 1996).
- Long-term DIN:OP ratios observed at the ambient monitoring station at Bridge St. (34A170[5]) also suggest that algae growth in the North Fork Palouse River is nitrogen-limited throughout the growing season (Table 8).

Table 8. Comparison of monthly median dissolved inorganic nitrogen and orthophosphate concentrations observed at the ambient monitoring station at Palouse (34A170), 1991-2012.

Month	Median DIN (mg/L)*	Median OP (mg/L)	DIN:OP ratio*
January	0.697	0.04215	16.5:1
February	1.0385	0.04075	25.5:1
March	0.707	0.036	19.6:1
April	<0.182	0.0243	<7.5:1
May	<0.0845	0.02	<4.2:1
June	<0.024	0.0171	<1.4:1
July	<0.02	0.016	<1.3:1
August	<0.02	0.0115	<1.7:1
September	<0.02	0.005	<4:1
October	<0.02	0.0061	<3.3:1
November	<0.02	0.014	<1.4:1
December	0.176	0.028	6.3:1

* DIN is calculated as the sum of Nitrate-Nitrite and Ammonia. The less-than symbol (<) is used when the median condition of Nitrate-Nitrite, Ammonia, or both is a non-detect. In this case, the actual DIN:OP ratio is unknown, but a maximum ratio can be calculated using the detection limit. Since the true value is less than the detection limit, the true ratio will be less than the calculated ratio.

Although many DO and pH TMDLs in Washington have focused on phosphorus-limitation, nitrogen-limitation in river systems is common in the Pacific Northwest, and in the Southwest (Borchardt, 1996) too. The Walla Walla River Basin pH and DO TMDL found nitrogen limitation in the Touchet River and Mill Creek (Joy et al, 2007). Data collected by Ecology in the Hangman Creek watershed during 2008-2009 also indicates nitrogen-limitation.

[5] Equivalent to 34PAL120.3 in this study.

Periphyton and macrophytes

Periphyton

Periphyton are a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that are attached to submerged surfaces in most Pacific Northwest aquatic ecosystems. The term "bottom algae" is sometimes used interchangeably with periphyton. In many rivers, including the North Fork Palouse River, periphyton growth is the primary contributor to total primary productivity. Periphyton photosynthesis and respiration are among the most important drivers of DO and pH in many rivers of Washington State.

Figure 9 shows the periphyton areal[6] photosynthetic biomass measured at the end of the summer growing season in 2007. Periphyton biomass was noticeably elevated downstream of Palouse WWTP (34PAL118.9; Figure 10), which is also the site with the highest observed DIN. Biomass was also noticeably elevated downstream of the floodworks in Colfax, which is the only other site that had detectable DIN (See also Figure 8).

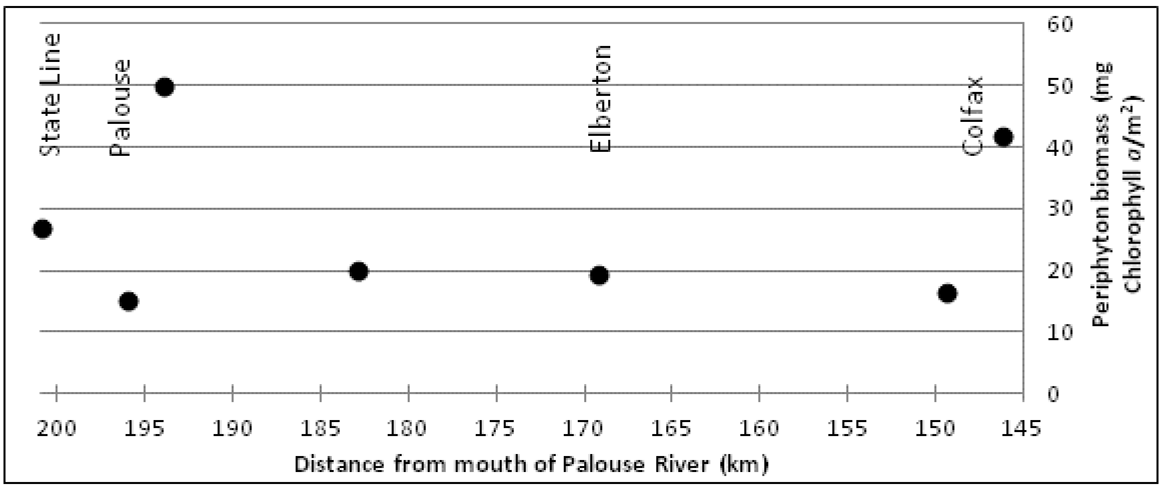


Figure 9. Periphyton areal photosynthetic biomass measured September 4, 2007.

Even at locations where DIN concentrations were below detectable levels, and where no obvious sources of nitrogen were nearby, periphyton was observed, albeit in lower biomass than at sites with detectable DIN. Periphyton biomass in locations without detectable DIN ranged from 15 to 27 mg chlorophyll-*a*/m^2 [7]. This is similar to results found by Biggs (1996) who found a median value of 21 mg chlorophyll *a*/m^2 across streams in New Zealand that were considered moderately enriched in catchments moderately developed for agriculture.

[6] Areal: Measured with respect to area. For example, areal periphyton and macrophyte biomass are typically expressed in units such as mg/m^2.

[7] Chlorophyll *a* is the most important form of chlorophyll used by photosynthetic organisms, and is measured as an indicator for of photosynthetic biomass.

Figure 10. View of the North Fork Palouse River at Highway 272 near Palouse (34PAL118.9), showing periphyton covering the streambed.

The periphyton is visible in this photo as a greenish tint on the rocks and the streambed. (This photo is best viewed electronically)

Macrophytes

Macrophytes are aquatic plants that grow in or near water and are emergent, submergent, or floating. Macrophytes contribute to primary productivity, and they have the ability to take up nutrients from streambed sediments through their roots. These nutrients can later be released into the water column.

Macrophytes collected from the North Fork Palouse River were not identified to species. However, common macrophyte species identified on the nearby South Fork Palouse River include *Elodea canadensis* (common waterweed), *Stuckenia filiformis* (slender-leaved pondweed), *Potamogeton crispus* (curly leaf pondweed), and *Lemna sp.* (duckweed).

Figure 11 shows macrophyte areal biomass. Distribution of macrophyte biomass in the North Fork Palouse River was observed to be patchy. Certain sites exhibited large quantities of macrophytes growing in clumps or beds (Figure 12), while other sites had very few.

Macrophyte biomass did not appear to be linked to instream nutrient concentrations. This would be expected because macrophytes can take up nutrients from the streambed.

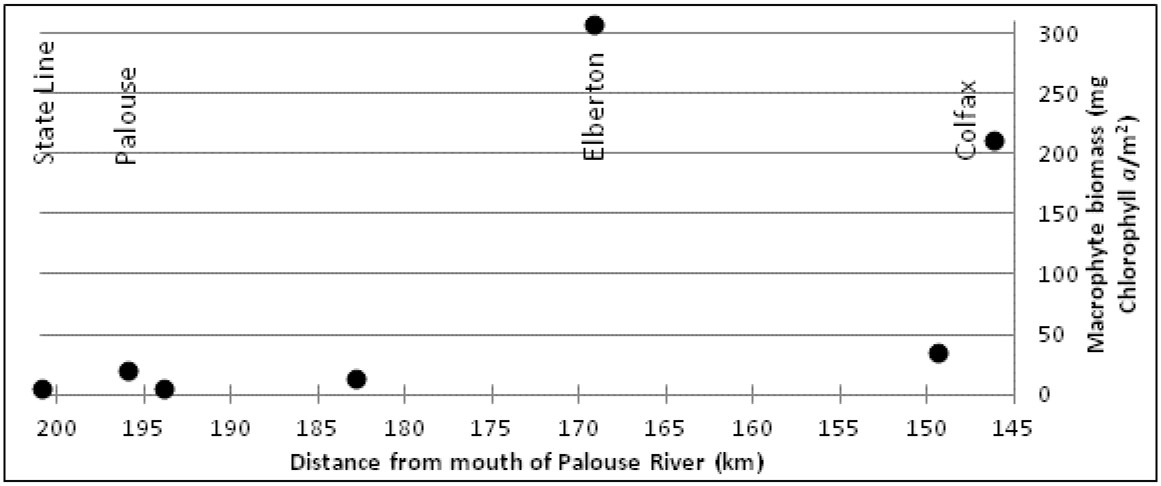


Figure 11. Macrophyte photosynthetic biomasses measured September 4, 2007.

Figure 12. Macrophytes growing in a clump at Lange Rd., near Elberton.

Dissolved oxygen and pH

Table 9 shows the daily minimum and maximum dissolved oxygen (DO) and pH observed in the North Fork Palouse River on July 30-31, 2007, August 27-28, 2007, and September 17-19, 2012. Figure 13 shows this same data graphically, referenced to location along the river. DO concentrations of less than 8 mg/L and pH values greater than 8.5 S.U. (values outside water quality criteria) were generally observed at all sampling locations.

Table 9. Daily maximum and minimum dissolved oxygen and pH measured in the North Fork Palouse River in 2007 and 2012.

*Values outside the water quality criteria are shown in **bold italics**.*

Dissolved Oxygen								
Location ID	Location Description	Jul 30-31, 2007		Aug 27-28, 2007		Sep 17-19, 2012		DO criteria
		DO Max	DO Min	DO Max	DO Min	DO Max	DO Min	
34PAL124.3	Palouse River at State Line	11.70	***5.28***	11.75	***7.07***	10.91	***7.23***	≥8
34PAL122.2	Palouse River nr Loop Rd.					11.19	***7.57***	≥8
34PAL120.8	Palouse River at S. River Rd.					10.85	***7.32***	≥8
34PAL120.3	Palouse River at Bridge St.	12.63	***6.48***	10.76	8.16	11.01	***7.69***	≥8
34PAL120.0	Palouse River at Main St.					9.92	***7.98***	≥8
34PAL118.9	Palouse River at Hwy 272	15.26	***3.42***	20.25	***3.93***	17.45	***5.86***	≥8
34PAL116.8	Palouse River at Duffield Ck.					11.23	8.42	≥8
34PAL112.4	Palouse River at Altergott Rd.	11.30	***5.58***	11.76	***6.83***	10.32	***7.54***	≥8
34PAL103.9	Palouse River at Elberton	11.34	***6.22***	11.47	***7.03***			≥8
34PAL98.3	Palouse River at Glenwood	11.12	***5.59***	11.63	***6.52***			≥8
34PAL91.7	Palouse River above Colfax			11.99	***6.62***			≥8
34PAL91.5	Palouse River abv SF Palouse confluence	9.67	***6.68***	9.97	***7.20***			≥8
34SIL00.0	Silver Creek at mouth	9.54	***6.27***	10.62	***7.90***			≥8
pH								
Location ID	Location Description	Jul 30-31, 2007		Aug 27-28, 2007		Sep 17-19, 2012		pH criteria
		pH Max	pH Min	pH Max	pH Min	pH Max	pH Min	
34PAL124.3	Palouse River at State Line	***8.93***	7.11	***8.76***	7.16	***8.67***	7.43	6.5 - 8.5
34PAL122.2	Palouse River nr Loop Rd.					***8.96***	7.43	6.5 - 8.5
34PAL120.8	Palouse River at S. River Rd.					***8.95***	7.73	6.5 - 8.5
34PAL120.3	Palouse River at Bridge St.	***9.79***	***8.94***	***9.13***	***8.70***	***8.78***	7.48	6.5 - 8.5
34PAL120.0	Palouse River at Main St.					***8.53***	7.75	6.5 - 8.5
34PAL118.9	Palouse River at Hwy 272	***10.22***	***8.89***	***10.31***	7.61	***9.98***	7.31	6.5 - 8.5
34PAL116.8	Palouse River at Duffield Ck.					***9.30***	***9.09***	6.5 - 8.5
34PAL112.4	Palouse River at Altergott Rd.	***9.50***	7.68	***9.12***	7.34	***9.00***	7.70	6.5 - 8.5
34PAL103.9	Palouse River at Elberton	***9.46***	7.64	***9.75***	8.25			6.5 - 8.5
34PAL98.3	Palouse River at Glenwood	***9.98***	8.03	***9.59***	7.82			6.5 - 8.5
34PAL91.7	Palouse River above Colfax			***8.92***	7.36			6.5 - 8.5
34PAL91.5	Palouse River abv SF Palouse confluence	***8.70***	7.68	***8.98***	7.90			6.5 - 8.5
34SIL00.0	Silver Creek at mouth	7.92	7.43	8.15	7.71			6.5 - 8.5

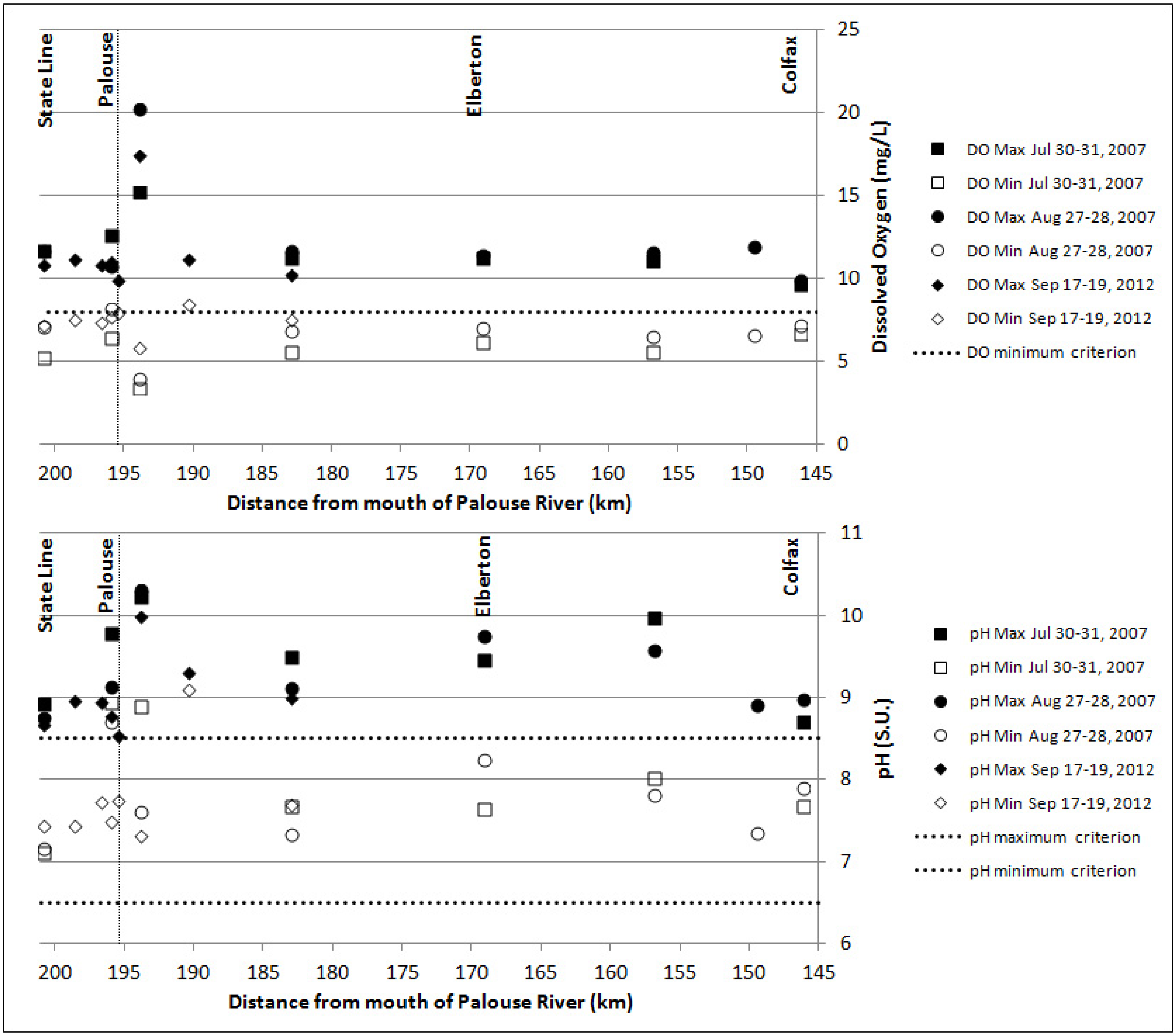


Figure 13. Daily maximum and minimum DO and pH measured in the North Fork Palouse River in 2007 and 2012.

The vertical dashed line represents the location of the Palouse WWTP outfall. The results that appear to be at the exact location of the outfall were actually taken just upstream of it (34PAL120.0). Results from Silver Creek (34SIL00.0) are not shown on this graph.

Hourly DO and pH values exhibit a diel swing pattern throughout the North Fork Palouse River. Daily maximum DO and pH values occur during the afternoon, while daily minimum DO and pH values occur during the late evening or early morning. This pattern is typical of streams where DO and pH are driven largely by algal productivity.

These diel swings become extreme in the reach downstream of the city of Palouse. The monitoring site at Hwy 272 (34PAL118.9), which is located one mile downstream of the Palouse WWTP outfall, saw the highest and the lowest DO concentrations, as well as the highest pH observed during the study. DO concentrations ranging from 3.42 to 20.25 mg/L and pH as high as 10.31 were measured at this location (Figure 14).

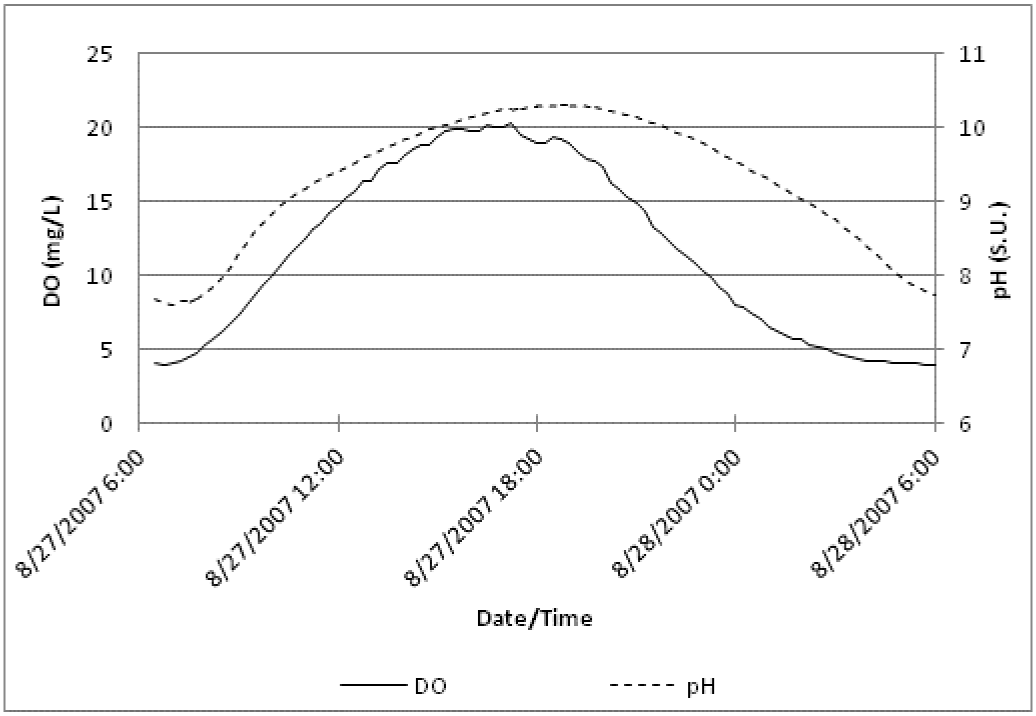


Figure 14. Diel DO and pH measured in the North Fork Palouse River at Hwy 272 (34PAL118.9) on August 27-28, 2007.

In a few locations, the diel swing of pH in the water remained high (or stuck) throughout the day and night (most locations had observed pH swings from an early morning pH around 7.0 to a late afternoon pH above 9.0). One example of "stuck" high pH was observed in the Palouse River at Duffield Ck. (34PAL116.8) on September 18-19, 2012, when early morning pH was always above 9.0. This is discussed further in the "Model Results and Discussion" section.

Field Study Summary and Conclusions

Summarized findings of the field study include:

- Water velocities are slow and travel times are long in the North Fork Palouse River during low-flow conditions. This means that downstream transport of pollutants is reduced and water quality impacts from pollutants are more localized.
- DIN:OP ratios indicate productivity in the river is nitrogen-limited.

- Dissolved inorganic nitrogen (DIN), which includes the forms of nitrogen available to be taken up and used by algae and aquatic plants, occurs at or below detectable levels in most locations. The highest levels of detectable DIN were observed below the Palouse WWTP.
- Even though there were low levels of nutrients throughout most of the river, there were still moderate levels of periphyton biomass throughout the river. However, the highest levels of periphyton photosynthetic biomass were observed at locations where DIN was above detectable levels.
- Observed hourly DO and pH levels fluctuated through the day throughout the length of the river, with daily maximum DO and pH levels occurring during the afternoon, and daily minimums occurring during the late evening or early morning. At the sampling location below Palouse WWTP, which has elevated DIN levels as well as elevated periphyton biomass, the magnitude of this diel swing was the greatest, indicating a high level of productivity.

The data collected during this study supports the conclusion that productivity in the North Fork Palouse River is most limited by dissolved inorganic nitrogen (DIN). Any addition of DIN to the river is likely to cause a “spike” in productivity, resulting in eutrophic and unacceptable levels of low DO and high pH. Controlling DO and pH problems in the North Fork Palouse River will require controlling inputs of DIN.

Model results and discussion

Water quality and productivity dynamics (periphyton production, pH, DO, and nutrients) were simulated in the North Fork Palouse River using the QUAL2Kw numerical model. The model calibration and sensitivity tests confirmed that productivity in the North Fork Palouse is controlled by DIN. DIN controls excessive periphyton growth, which in turn controls excessive DO and pH diel swings. The model was used to develop assimilative load capacities for DIN.

Appendix C contains details about model structure, inputs, calibration, and model quality. The following section is a general summary of model findings.

The QUAL2Kw model was able to accurately simulate water quality in the North Fork Palouse River. Figure 15 shows modeled and observed daily minimum and maximum DO and pH for two field survey dates. Appendix C, subheading “Model Goodness-of-fit” contains additional plots of modeled and observed values for all key parameters simulated, and all survey dates.

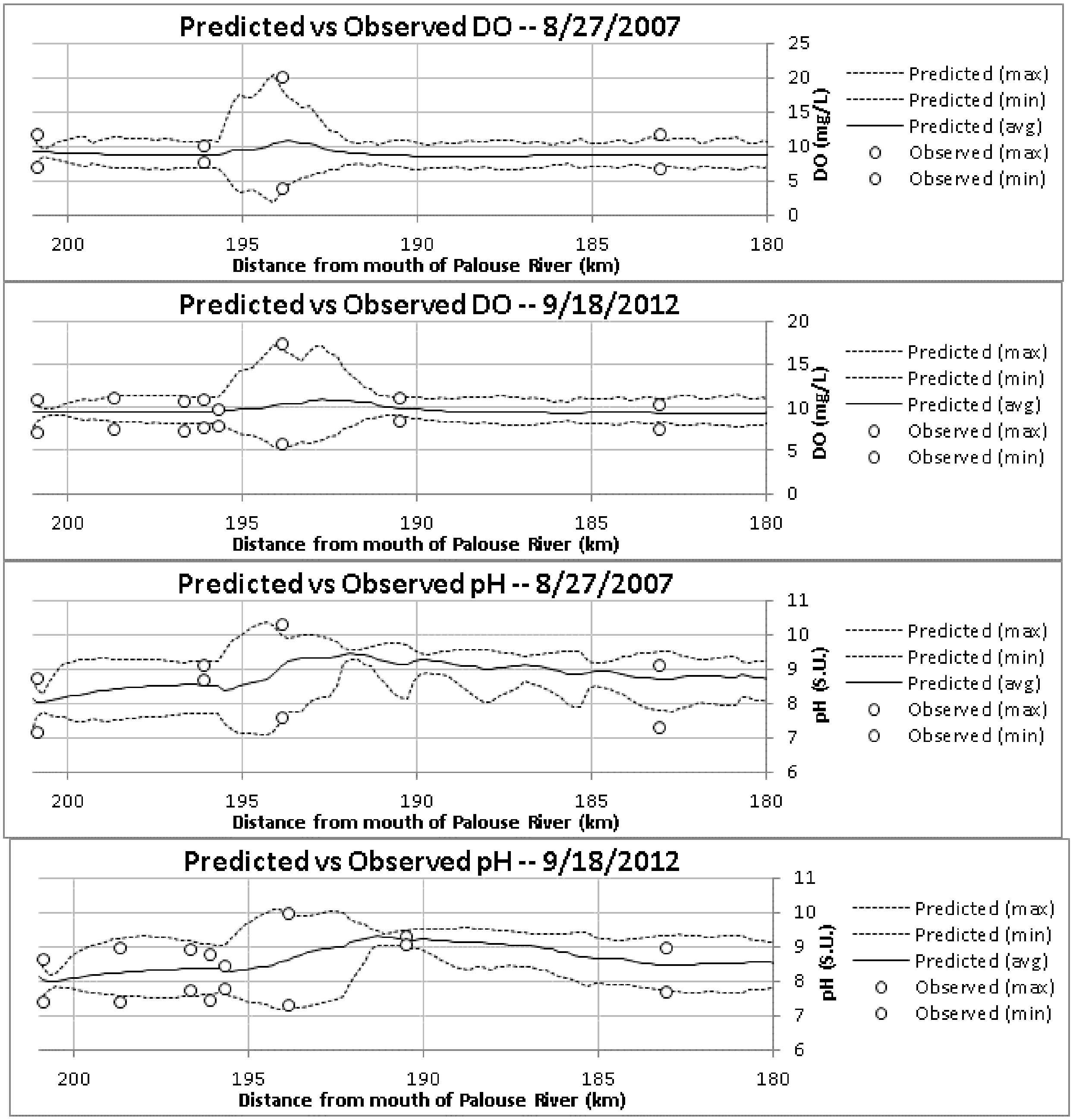


Figure 15. Modeled and observed daily minimum and maximum dissolved oxygen and pH for August 27, 2007 and September 17, 2012.

Palouse WWTP is located at 195.5km.

Diel variability of dissolved oxygen and pH

The North Fork Palouse River is a productive water body, with diel variability of DO and pH being driven largely by the photosynthesis and respiration of periphyton and macrophytes. The model predicts that it is primarily periphyton that control DO and pH levels in the North Fork Palouse River, with macrophytes playing a secondary role.

During daylight hours, periphyton and macrophyte photosynthesis outpaces respiration. When this happens, DO increases in the water column. At the same time, the photosynthesis depletes dissolved carbon dioxide, raising the pH of the water. At night, the opposite happens. Photosynthesis ceases, and respiration dominates, depleting DO and at the same time increasing dissolved carbon dioxide, which reduces pH. Natural reaeration processes in the North Fork Palouse River cannot keep pace with this periphyton and macrophyte-driven gas exchange. As a result, DO and CO_2 levels "swing" far above and below their saturation points during the course of 24 hours. The large CO_2 swings produce large pH swings.

Dissolved inorganic nitrogen

The model is able to explain the eutrophic DO and pH diel ranges in the reach downstream of Palouse as a result of DIN discharged by Palouse WWTP. The additional DIN supply causes periphyton growth to increase, driving larger swings in DO and pH. Uptake of DIN by periphyton causes the supply of DIN to be exhausted within a few kilometers downstream of the discharge. After this, periphyton growth rates return to normal and DO and pH diel ranges gradually return to normal ranges.

The model predicts that the North Fork Palouse River is very sensitive to additions of DIN during low-flow conditions. Because background concentrations of DIN are near zero, even a very small input of DIN to the river is expected to cause immediate increase in productivity and deleterious changes in DO and pH.

Biochemical oxygen demand

Biochemical oxygen demand (BOD) is the term used to describe the depletion of DO from the water by the oxidation of organic substances. The patterns observed in the DO, ammonia, and dissolved organic carbon data indicate that BOD is not a primary contributor to DO problems in the North Fork Palouse River. Rather, the vast majority of DO impacts in the North Fork Palouse River are the result of algal productivity.

The calibrated QUAL2Kw model was used to assess the likely BOD impact on DO from current operation of Palouse WWTP. This was done by assuming a decay rate *k* of 0.075/d, a typical rate for effluent from an activated sludge treatment plant (Chapra, 1997). The model predicts that discharge from Palouse WWTP at the monthly permit limit of 10mg/L BOD5 would have a 0.05 mg/L impact on DO.

Round-the-Clock high pH

In a few locations, the daily swing of pH in the water remained high (or stuck) throughout the day and night (most locations had observed pH swings from an early morning pH around 7.0 to a late afternoon pH above 9.0).

The most extreme example of "stuck" high pH was observed in the Palouse River at Duffield Ck. (34PAL116.8) on September 18-19, 2012, when early morning pH was always above 9.0. The QUAL2Kw model simulates this "stuck" high pH as the result of near-total depletion of carbon dioxide (CO_2) from the water as it passes through the highly eutrophic reach below the Palouse WWTP. Figure 16 shows modeled and observed pH for September 18, 2012, alongside modeled aqueous carbon dioxide (CO_2). The "stuck" pH occurs downstream of the eutrophic reach in a reach where algal productivity returns to normal levels because the DIN is also exhausted. Round-the-clock or "stuck" high pH is predicted to be a part of the recovery pattern for pH downstream of any large DIN source on the North Fork Palouse River.

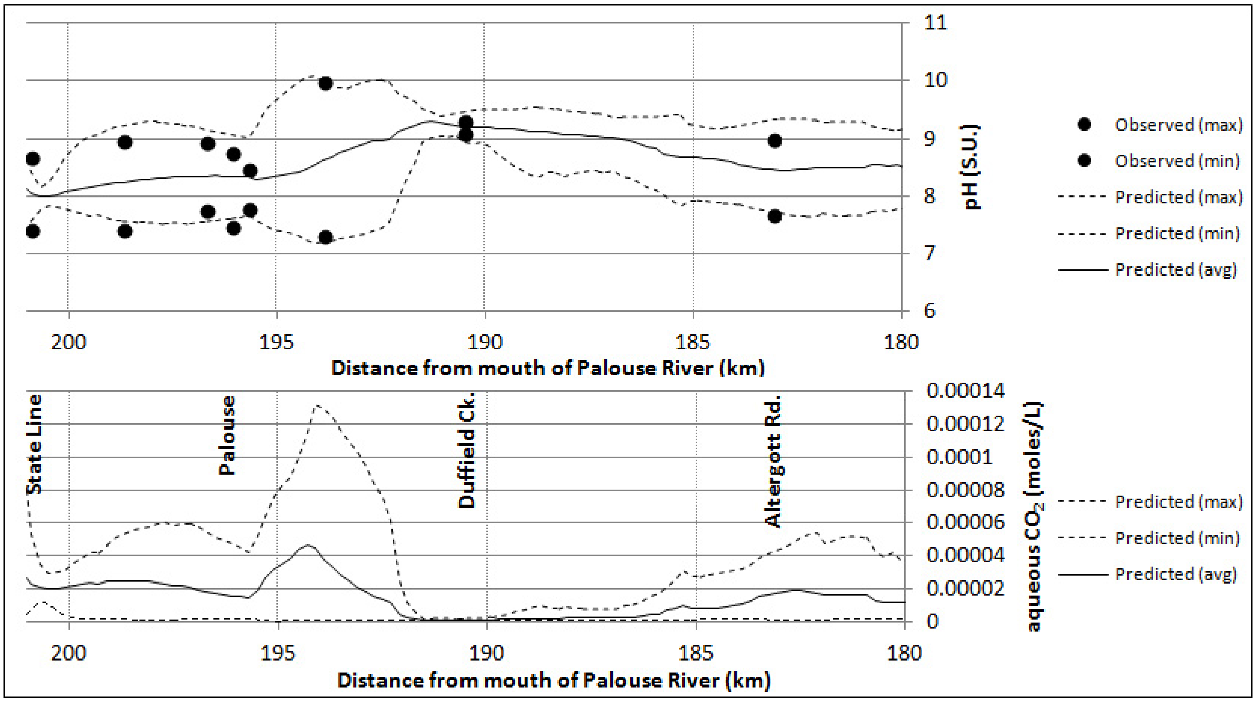


Figure 16. pH and aqueous CO_2 predicted by the QUAL2Kw model for September 18, 2012, along with observed pH for reference.

Depletion of CO_2 results in high pH, while higher concentrations of CO_2 result in lower pH.

Additional occurrences of round-the-clock high pH were observed during 2007, but not during 2012, in the Palouse River at Bridge Street. (34PAL120.3). Appendix D presents a model scenario that may explain these data. This model scenario suggests that septic systems located near the upstream end of the city of Palouse may have been contributing nutrients to the river which were creating an impact to DO and pH. Sewer extension completed by the city of Palouse during 2007-2008 may have eliminated this source, explaining why no such pattern was observed during 2012.

System potential conditions

The calibrated QUAL2Kw model was used to estimate the DO and pH that would be expected to occur under system potential conditions. System potential conditions are conditions that do not include human modifications to riparian vegetation, or anthropogenic nutrient sources. The system potential condition also serves as an estimate of natural conditions.

To estimate system potential condition DO and pH, the QUAL2Kw model was modified in the following ways:

- The Palouse WWTP effluent discharge was removed from the simulation.
- The shade inputs were changed to reflect system potential riparian vegetation, as calculated in the Palouse River Temperature TMDL (Snouwaert and Stuart, 2013).
- The upstream end of the model domain and tributary boundary conditions were modified to reflect estimated system potential temperature, DO, pH, and nutrient loads.

Complete documentation of the model inputs and values used can be found in Appendix C under the heading "System Potential Conditions Model Inputs."

It was not possible to accurately include all human modifications to the river system in the model. Some known or suspected human modifications were omitted, including changes to channel geometry and streamflow. Analysis of these factors is outside the scope of this study, and they are not typically addressed directly by TMDL allocations. However, these conditions could be addressed as part of the implementation, and could add to the restoration of the river beyond the benefits of pollutant loading reductions.

System potential conditions were simulated continuously for the time period from July 1 to September 30, 2007. Figure 17 presents the simulation results for both current and system potential conditions for August 17, 2007. This date represents a day with hot summer temperatures and the lowest 7-day average flows that would be expected to occur once every 10 years (7Q10).

Sensitivity analyses show that, of the several model inputs that were altered to represent system potential conditions, the two that make a significant difference for DO and pH are: 1) the inorganic nitrogen component of the effluent from Palouse WWTP; and 2) system potential shade. The brackets and labels in Figure 17 give a visual representation of the relative impact of these two factors. The removal of inorganic nitrogen discharged by Palouse WWTP is expected to improve daily minimum DO by up to 4.7 mg/L, and daily maximum pH by up to 0.95 S.U. The shade produced by system-potential mature riparian vegetation is expected to improve daily minimum DO values by up to 0.8 mg/L, and daily maximum pH values by up to 0.16 S.U. Other factors, such as boundary loads of phosphorus and inorganic nitrogen, did not have an appreciable impact. See Appendix C, heading "Sensitivity Analysis Scenarios" for more information.

The QUAL2Kw model predicts that, under system potential conditions:

- The size of diel swings in DO and pH values would be significantly reduced in the reach downstream of Palouse WWTP due to the removal of inorganic nitrogen, and reduced to a lesser extent elsewhere due to the addition of shade.
- Daily minimum DO would be significantly increased in the reach downstream of Palouse WWTP, and to a lesser extent elsewhere.
- Daily maximum pH would be significantly reduced in the reach downstream of Palouse WWTP, and to a lesser extent elsewhere.
- There would be no instances of round-the-clock high pH.

The model predicts that even under system potential conditions, there would be diel swings in DO and pH throughout the system. There are two main reasons for this. First, even without direct sources of DIN, a small amount of background periphyton productivity is expected to occur. Second, the wide channel and low flows mean that this background productivity is still able to have an impact on DO and pH.

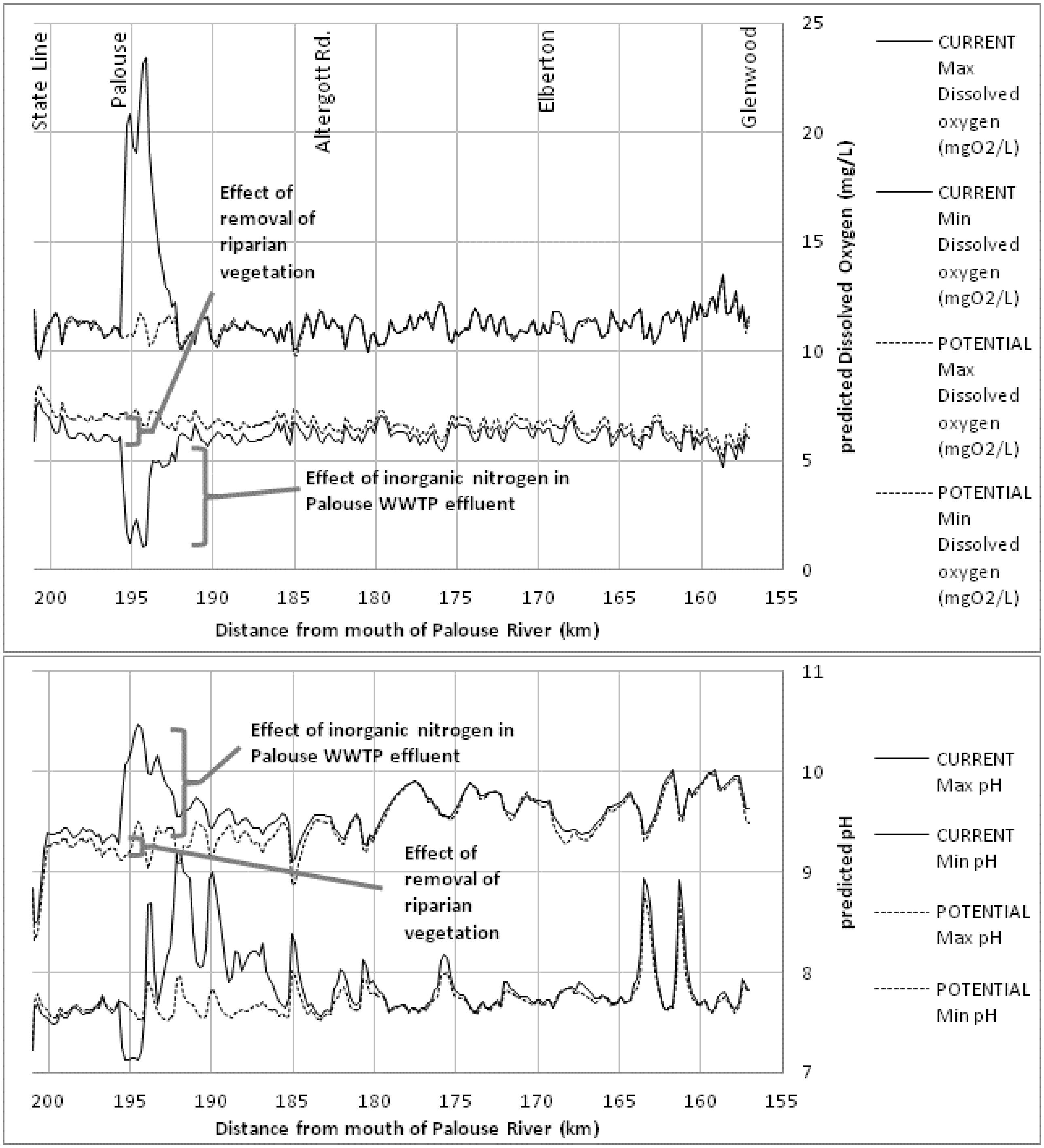


Figure 17. Predicted daily maximum and minimum dissolved oxygen and pH under current and system potential conditions, for August 17, 2007.

Seasonal variation

DO and pH vary throughout the course of the year. Exceedences of numeric criteria in the North Fork Palouse River occur mainly during the summer months, when streamflows are low and temperatures are high.

Figure 18 shows DO data collected by Ecology's ambient monitoring program at Bridge Street in Palouse (34A170). Figure 19 shows pH data collected at the same station. This station is located just upstream of the Palouse WWTP outfall.

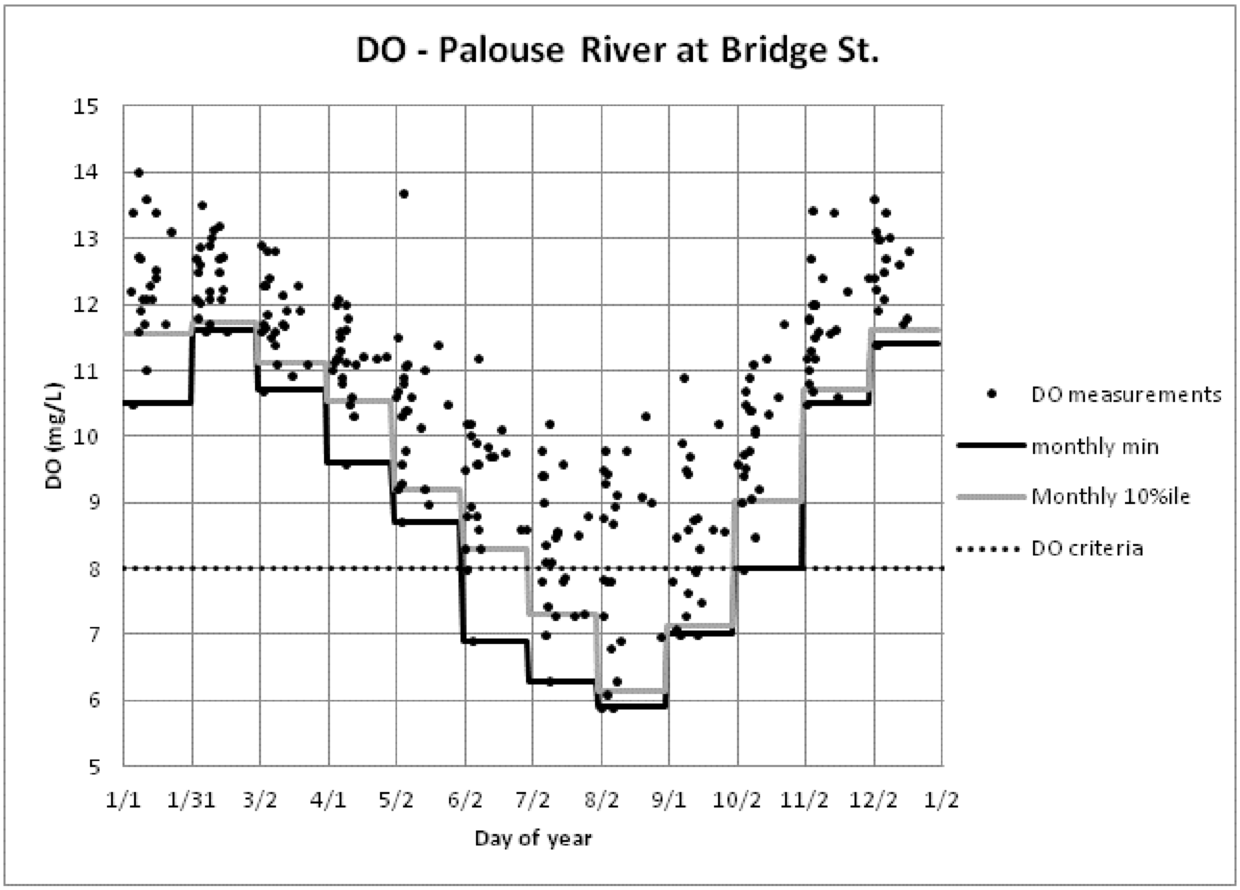


Figure 18. Dissolved oxygen data collected by Ecology's ambient monitoring program from 1974-2012 in the Palouse River at Bridge Street (34A170)

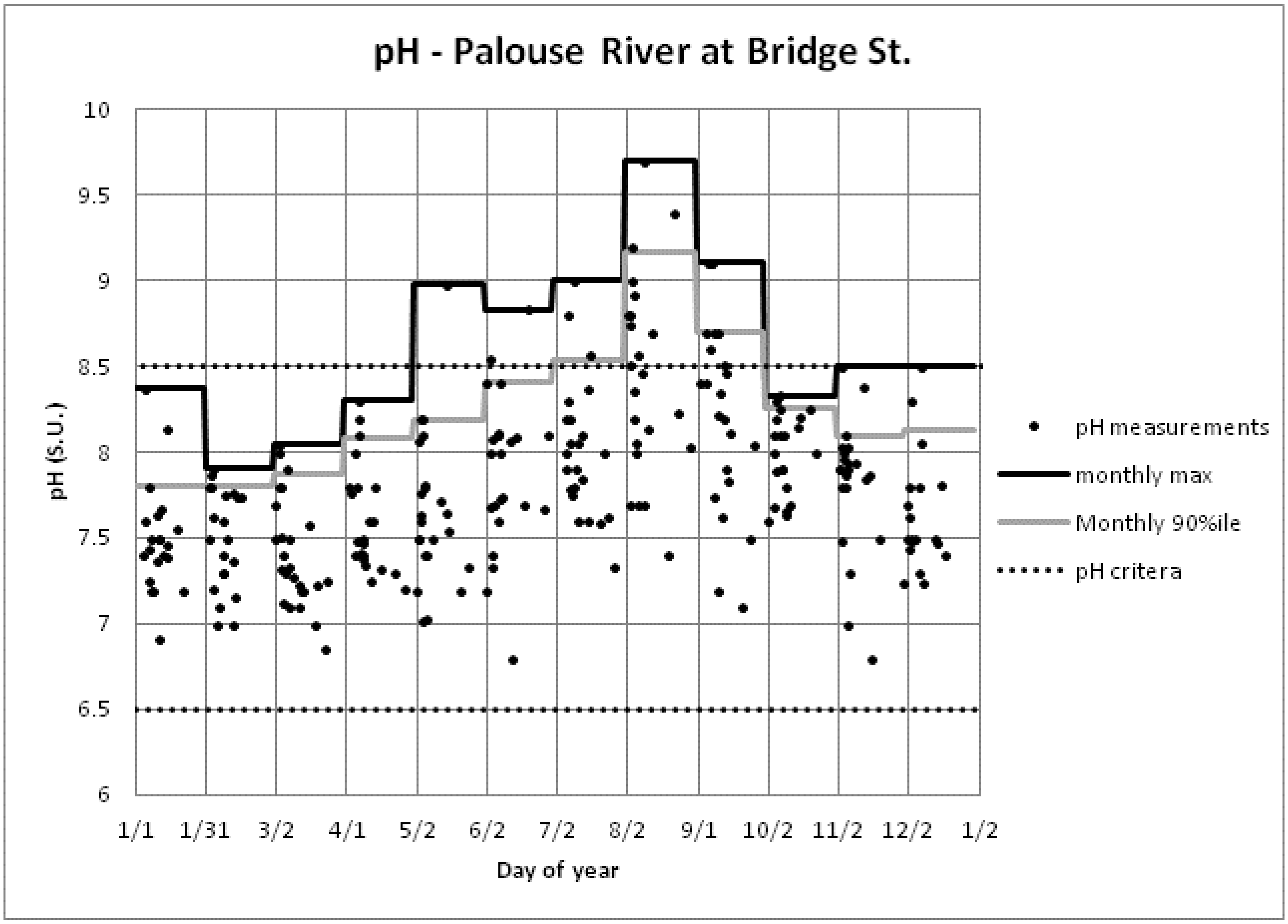


Figure 19. pH data collected by Ecology's ambient monitoring program from 1974-2012 in the Palouse River at Bridge Street (34A170)

Dissolved oxygen (DO) and/or pH data have exceeded numeric criteria during May, June, July, August, and September. Although exceedances have not occurred during October, October is also considered to be at risk because extreme low flows and warm, summer-like weather often persist into October. Therefore, May through October is defined as the critical period for this TMDL.

Loading capacity

The loading capacity of a river system is defined as the amount of a pollutant that can be added to the river without causing an exceedance of the water quality standards. Because both DO and pH are predicted to exceed the numeric criteria during the critical season even under system potential conditions, the loading capacity for this TMDL is based on ensuring that the total human impact does not exceed:

- 0.2 mg/L change to DO
- 0.1 S.U. *de minimis* change to pH

Essentially to meet water quality standards, the river must meet levels consistent with what would occur under natural conditions.

Sensitivity analysis using the calibrated QUAL2Kw model indicates that the amount of dissolved inorganic nitrogen needed to create a 0.2 mg/L DO change is less than the amount needed to create a 0.1 S.U. pH change. Therefore, the loading capacity is limited by DO.

To protect DO, loading capacities have been evaluated for biochemical oxygen demand (BOD) as well as for dissolved inorganic nitrogen (DIN).

Biochemical oxygen demand

As previously discussed in detail, the QUAL2Kw model predicts that discharge from Palouse WWTP at the monthly permit limit of 10 mg/L BOD5 would have a 0.05 mg/L impact on DO. Based on this assessment, the loading capacities for biochemical oxygen demand in the North Fork Palouse River are designed to ensure that any BOD discharges will not have greater than a 0.05 mg/L impact on DO. The remaining 0.15 mg/L DO impact is assigned to DIN.

The model predicts that BOD does not have an appreciable impact on pH.

Table 10 presents the loading capacities for BOD in the North Fork Palouse River.

Table 10. May-October Loading capacity for biochemical oxygen demand in the North Fork Palouse River.

BOD type	Characteristic decay rate *k* (/day) [1]	Loading capacity for BOD5 (kg/day) at 7Q10 flows
Palouse WWTP effluent	0.075 [2]	2.0
Nonpoint/ambient	0.066 [3]	0.84

[1]The decay rate refers to the portion of organic matter that is oxidized per day. For example, *k*=0.075 means that 7.5% of the remaining organic matter is oxidized per day.
[2]Typical rate for effluent from activated sludge treatment plant (Chapra, 1997).
[3]Decay rate was not measured for Palouse River. This is the CBOD value that was used in the Spokane River and Lake Spokane TMDL CE-QUAL-W2 model for Hangman Ck. and the Little Spokane River, based on ultimate BOD (uBOD) data collected from those locations (Portland State University, 2011; Cusimano, 2003). The vast majority of BOD in the Palouse River is likely to be CBOD, therefore it is reasonable to use this rate.
[4]BOD loading capacities are shown as 5-day BOD (BOD5). This is a typical laboratory test used to assess BOD.

Dissolved inorganic nitrogen

The North Fork Palouse River does not typically have detectable loads of dissolved inorganic nitrogen (nitrate-nitrite or ammonia) during the critical period. Because DO and pH are tied to algal productivity, and because productivity is limited by dissolved inorganic nitrogen availability, any input of dissolved inorganic nitrogen (DIN) will have an impact on DO and pH. Figure 20 presents the relationship between inorganic nitrogen load (as nitrate) and impact to DO and pH at extreme low flow (7Q10; 1.74 cfs) conditions. As shown by these graphs, the relationship is far from being a linear one. Rather, a very small nitrate load can have a very large impact.

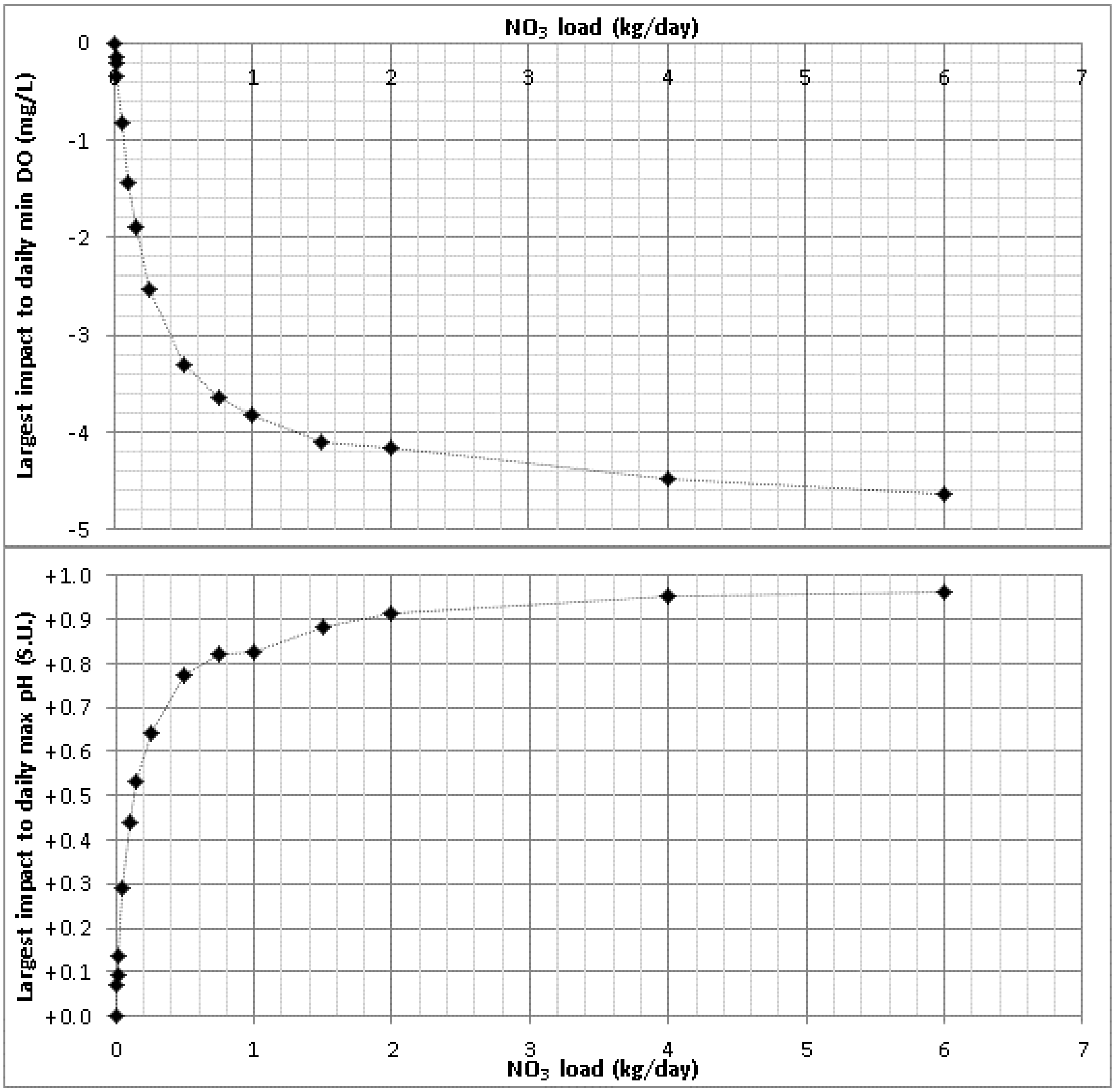


Figure 20. Predicted load/impact curves for the effect of nitrate from Palouse WWTP on dissolved oxygen and pH at 7Q10 flow, assuming system potential conditions other than this load.

Current condition DIN load from Palouse WWTP during August is 6.5 kg/day, which is 99.8 percent nitrate-nitrite. This curve varies somewhat at locations other than Palouse WWTP.

However, it is important to note that algal productivity is ultimately a function, not of limiting nutrient load, but rather of limiting nutrient concentration (Borchardt, 1996; Bothwell, 1985, Bothwell, 1989). Therefore, the relationship between dissolved inorganic nitrogen load and DO/pH impact shown in Figure 20 will change depending on streamflow in the receiving water, and the amount of dilution that results.

As explained earlier, the loading capacity for the North Fork Palouse River is based on a 0.2 mg/L change to DO. However, because 0.05 mg/L of this is assigned to BOD, only the remaining 0.15 mg/L of change can be assigned to DIN. Table 11 shows the loading capacities for DIN.

Table 11. Loading capacity for DIN in the North Fork Palouse River.

Upstream end of reach	Downstream end of reach	Acceptable loading capacity for DIN [1] at 7Q10 flow (kg/day)
201 km (State line)	196 km (Bridge St. in Palouse)	0.010
196 km	191 km (just abv Duffield Ck.)	0.0095
191 km	186 km (just abv Cedar Ck.)	0.011
186 km	181 km (~2km blw Altergott Rd.)	0.021
181 km	176km (just blw Lange Rd.)	0.017
176 km	171 km (~2km abv Elberton)	0.021
171 km	166 km (~3km blw Elberton)	0.020
166 km	161 km (~4km abv Glenwood)	0.017
161 km	156 km (~1km blw Glenwood)	0.014
156 km	151 km (~2km abv Colfax golf course)	0.014 [2]
151 km	146 km (SF Palouse R. confluence)	0.010 [3]

[1] Assumes DIN consists of nitrate. If DIN contains ammonia, multiply [ammonia fraction x 1.1] to find equivalent nitrate load. (See section below for explanation and example)
[2] This reach was not modeled. It is similar to the reaches directly upstream. Therefore a conservative load capacity estimate of 0.014 kg/day is used.
[3] This reach was not modeled. It contains a large, deep pool upstream of the Colfax floodworks. Therefore the load capacity from the deepest modeled reach, 0.010 kg/day, is used.

Ammonia vs. Nitrate

All loading capacities are calculated based on the assumption that dissolved inorganic nitrogen consists of nitrate. This was done because most of the DIN currently being discharged to the system is nitrate. However, ammonia, which is the other form of inorganic nitrogen, is more harmful to water quality and aquatic life than nitrate. Like nitrate, ammonia is readily available for uptake by periphyton. Ammonia has the following characteristics:

- Periphyton and other algae will preferentially take up ammonia rather than nitrate if both are available. However, both ammonia and nitrate have a similar impact on periphyton growth.
- Ammonia can be nitrified in the stream channel. This chemical process consumes oxygen, resulting in an overall lower concentration, or “sag” in DO. This was mentioned previously as nitrogenous biochemical oxygen demand.
- Ammonia becomes toxic under high pH conditions, such as those that occur during the afternoon at low flow on the North Fork Palouse River.

Ecology has analyzed the ammonia toxicity that would result from meeting the DIN load capacity described previously. Even if 100 percent of the permissible DIN load consisted of ammonia, and assuming extreme pH and temperature conditions, there would not be a violation of the water quality standards for ammonia toxicity (Table 12). This is because the DIN load capacities are very small, which equates to extremely low instream concentrations of DIN downstream of any source. Therefore, the load and wasteload allocations in this TMDL, which are primarily designed to protect DO and pH, will also be protective of ammonia toxicity.

Table 12. Worst-case analysis of ammonia toxicity resulting from DIN allocations in this TMDL.

Scenario	pH [1]	Temp [2]	DIN Load (kg/day) [3]	$NH_4 - N$ (mg/L) [4]	Unionized NH_3 (mg/L)	Acute Limit (mg/L)	Chronic Limit (mg/L)	Violates Acute?	Violates Chronic?
Loading capacity for DIN at 196-191 km	10.5	30	0.0095	0.0022	0.0021	0.29	0.042	no	no
	10.5	5	0.0095	0.0022	0.0018	0.29	0.021	no	no
Loading capacity for DIN at 186-181 km	10.5	30	0.021	0.0049	0.0047	0.29	0.042	no	no
	10.5	5	0.021	0.0049	0.0039	0.29	0.021	no	no

[1] These pH values are extreme, and are higher than is expected to ever occur in the North Fork Palouse River, even under current conditions. This is a conservative assumption for purposes of evaluating ammonia toxicity.
[2] Upper and lower ranges of temperatures likely to occur during the critical period.
[3] From Table 11.
[4] This is the instream concentration that would result from discharge at the loading capacity for DIN. However, a conservative assumption here is made that the entire DIN load consists of ammonia.

The QUAL2Kw model was used to estimate the relative DO and pH impacts of nitrate vs. ammonia. The model predicts that an ammonia load will have about a 10 percent greater impact on DO than an equivalent load of nitrate, due to the effects of NBOD. Therefore, if a DIN source contains ammonia, it is necessary to apply a correction factor of 1.1 to the ammonia fraction to account for its greater impact.

Example: If a source discharges 0.02 kg/day of nitrate and 0.01 kg/day of ammonia to the river, the corrected DIN load would be calculated as:

$$Corrected\ DIN = \left(0.02\frac{kg}{day}\right) + \left(0.01\frac{kg}{day} * 1.1\right) = 0.031\frac{kg}{day}$$

Distribution of loading capacity in system

In many river systems that have been studied in Washington, multiple sources cumulatively add nutrient loads which have a combined impact on DO and/or pH. For example, the Wenatchee River DO, pH, and Phosphorus TMDL (Carroll et al., 2006) and the Spokane River DO TMDL (Moore and Ross, 2010) both define load capacities in terms of phosphorus. These capacities are then divided, or allocated, between sources. This “pieces of a pie” approach to allocating load capacity is common and appropriate for systems like these.

The North Fork Palouse River functions very differently than rivers like the Wenatchee and the Spokane. During the summertime, stream velocities in the North Fork Palouse River become very slow (~0.05-0.2 ft/s; see Table 7), and times of travel are very long (~1-4 days for a 5km distance). The result of this is that each individual source of dissolved inorganic nitrogen has an effect that is localized, with DO and pH impairments occurring in a short reach downstream of the source.

Figure 21 presents QUAL2Kw predictions of impacts to DO and pH if a source of BOD and DIN creating a 0.2 mg/L impact to DO discharges once every 5km.

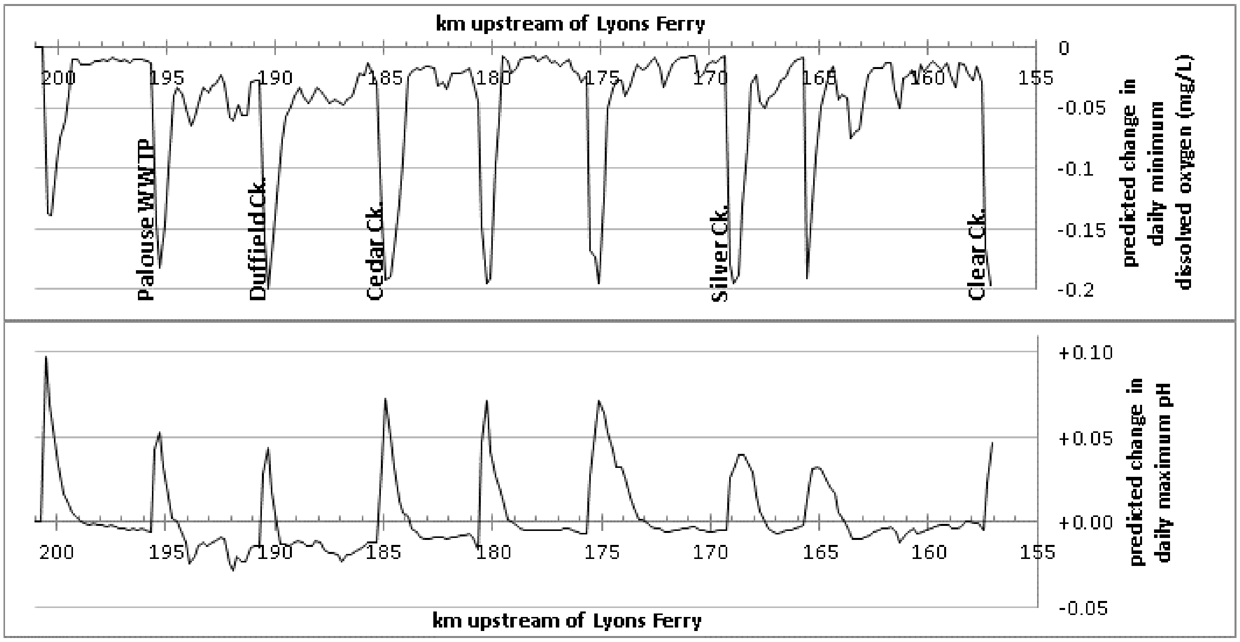


Figure 21. QUAL2Kw predictions of dissolved oxygen and pH impacts with a source discharging once every 5km.

Prediction is for 7Q10 conditions. The difference shown is the difference between system potential conditions scenario and system potential conditions + all sources scenario. Impact spikes at 200km, 180km, 175km, and 165km are hypothetical inputs of unspecified nonpoint sources.

As shown by Figure 21, within a short distance downstream of a source, DO and pH impacts dissipate. In effect, the loading capacity gets reset between each source. What this means is that, unless multiple sources occur within a close distance of one another, it is not necessary or appropriate to divide the loading capacity between sources like “pieces of a pie.” Rather, the loading capacity can be repeatedly assigned to successive sources, such as Palouse WWTP and each of the tributaries. This can be thought of as the “multiple separate pies” approach.

The QUAL2Kw model predicts that a 0.2 mg/L DO impact will entirely dissipate in a distance of 1 – 2km. However, this TMDL allows for a new discharge every 5km. This is a conservative approach that provides a built-in margin of safety.

It is acceptable for multiple sources to discharge to the same 5-km reach, but in this case they would have to divide the available loading capacity.

Upstream (Idaho) sources

It is possible that sources in Idaho could add nutrients or BOD to the North Fork Palouse River which could impact DO and pH in Washington. The city of Potlatch’s Wastewater Treatment Plant (WWTP), which is located approximately 10 miles upstream from the Washington/Idaho state line, discharges from November through July. This partly overlaps with the critical period for this TMDL. However, the findings of this study suggest that impacts from a municipal source would likely be limited to a shorter distance than 10 miles. Monitoring conducted during this study did not find any detectable concentrations of DIN at the state line. It is not expected that this TMDL will require any changes to current activities in Idaho. Future sources with significant loads of DIN or BOD should be evaluated for impacts to DO and pH in Washington state.

Load and wasteload allocations

Table 13 lists the discharges in the North Fork Palouse River DO-pH TMDL area that have National Pollution Discharge Elimination System (NPDES) permits.

Table 13. Dischargers in the TMDL area covered by NPDES Permits.

Permittee Name and ID	Permit ID	Permit type	Receiving Water Body	Critical Condition Period
Palouse WWTP	WA004806	Municipal IP	(North Fork) Palouse River	May - October
Washington State DOT[1]	WAR04000A	Municipal SW		
Empire Disposal	WAR010082	Industrial SW GP		
Seubert Excavators Portable Crusher 1	WAG500055	Sand and Gravel GP	Does not discharge	N/A

[1] WSDOT will become a permittee in this watershed following approval of this TMDL and incorporation into their NPDES municipal stormwater permit renewal in 2019.

Because the loading capacity in the North Fork Palouse TMDL can be repeatedly assigned to successive sources every 5 km without impairing DO and pH, the allocation approach used in this TMDL is to segment the river into 5-km sections. The loading capacity for each section is then assigned to a particular source, such as a facility or tributary, or to a combination of sources in a “bubble” allocation. Some sources, such as runoff from adjacent lands, are conveyed through Washington Department of Transportation (WSDOT) stormwater facilities. WSDOT’s facilities, the majority of which are ditches and culverts, discharge in multiple locations. These sources that discharge into more than one segment can therefore participate in more than one allocation.

Table 14 details the load capacity segmentation of the North Fork Palouse River used for this TMDL.

Seubert Excavators Portable Crusher 1 does not discharge, and so its wasteload allocation for both DIN and BOD is zero.

Table 14. Load capacity segmentation of the North Fork Palouse River

Upstream end of reach	Downstream end of reach	Type and coverage of allocation
201 km (State line)	196 km (Bridge St. in Palouse)	Bubble
196 km	191 km (just abv Duffield Ck.)	Individual for Palouse WWTP
191 km	186 km (just abv Cedar Ck.)	Bubble including Duffield Creek
186 km	181 km (~2km blw Altergott Rd.)	Bubble including Cedar Creek
181 km	176 km (just blw Lange Rd.)	Bubble
176 km	171 km (~2km abv Elberton)	Bubble
171 km	166 km (~3km blw Elberton)	Bubble including Silver Creek
166 km	161 km (~4km abv Glenwood)	Bubble including Brush Creek
161 km	156 km (~1km blw Glenwood)	Bubble including Clear Creek
156 km	151 km (~2km abv Colfax golf course)	Bubble
151 km	146 km (SF Palouse R. confluence)	Bubble

Palouse WWTP

The city of Palouse's WWTP discharges year-round to the Palouse River at River Mile 120 (kilometer 196; Figure 22). The plant, which was built in 1995, is an activated sludge facility which provides secondary treatment of Palouse's municipal wastewater. Palouse WWTP is currently the largest single source of dissolved inorganic nitrogen to the North Fork Palouse River, with an effluent load of about 6.5 kg/day of DIN during late summer.

Table 15 presents the wasteload allocations for dissolved inorganic nitrogen and biochemical oxygen demand for Palouse WWTP. The wasteload allocation applies from May through October. The wasteload allocation for dissolved inorganic nitrogen is based on streamflow in the receiving water. This reflects the fact that at higher flows, when more dilution is available, larger loads of DIN can be discharged without impairing DO and pH. The wasteload allocation for DIN is calculated using the following equation:

$$W = 0.0022 * Q_{US} * \left(\frac{28.3168 * 86{,}400}{1{,}000{,}000}\right)$$

Where:

W = Wasteload allocation for DIN (kg/day)

0.0022 = the acceptable DIN concentration downstream of discharge (mg/L; See Table 11; this is equivalent to a load of 0.0095 kg/day at 7Q10 streamflows)

Q_{US} = Palouse River streamflow measured at USGS Potlatch gage (cfs)

Explanation of unit multipliers:

28.3168 L = 1 cubic foot

86,400 seconds = 1 day

1,000,000 mg = 1 kg

Figure 22. Palouse WWTP outfall at Main Street bridge.

Palouse WWTP discharges effluent through the standpipe visible in the center of the photo.

Table 15. Wasteload allocations for Palouse WWTP.

Palouse River flow, measured at Potlatch USGS gage (cfs)	Wasteload Allocation for Dissolved Inorganic Nitrogen (kg/day)[1]	Palouse River flow, measured at Potlatch USGS gage (cfs)	Wasteload Allocation for Dissolved Inorganic Nitrogen (kg/day)[1]	Palouse River flow, measured at Potlatch USGS gage (cfs)	Wasteload Allocation for Dissolved Inorganic Nitrogen (kg/day)[1]	Palouse River flow, measured at Potlatch USGS gage (cfs)	Wasteload Allocation for Dissolved Inorganic Nitrogen (kg/day)[1]
0.1	0.00054	5.5	0.030	55	0.296	550	2.96
0.2	0.0011	6	0.032	60	0.323	600	3.23
0.3	0.0016	6.5	0.035	65	0.350	650	3.50
0.4	0.0022	7	0.038	70	0.377	700	3.77
0.5	0.0027	7.5	0.040	75	0.404	750	4.04
0.6	0.0032	8	0.043	80	0.431	800	4.31
0.7	0.0038	8.5	0.046	85	0.458	850	4.58
0.8	0.0043	9	0.048	90	0.484	900	4.84
0.9	0.0048	9.5	0.051	95	0.511	950	5.11
1	0.0054	10	0.054	100	0.538	1000	5.38
1.1	0.0059	11	0.059	110	0.592	1100	5.92
1.2	0.0065	12	0.065	120	0.646	1200	6.46
1.3	0.0070	13	0.070	130	0.700	1300	7.00
1.4	0.0075	14	0.075	140	0.754	1400	7.54
1.5	0.0081	15	0.081	150	0.807	1500	8.07
1.6	0.0086	16	0.086	160	0.861	1600	8.61
1.7	0.0092	17	0.092	170	0.915	1700	9.15
1.8	0.0097	18	0.097	180	0.969	1800	9.69
1.9	0.010	19	0.102	190	1.02	1900	10.2
2	0.011	20	0.108	200	1.08	2000	10.8
2.2	0.012	22	0.118	220	1.18	2200	11.8
2.4	0.013	24	0.129	240	1.29	2400	12.9
2.6	0.014	26	0.140	260	1.40	2600	14.0
2.8	0.015	28	0.151	280	1.51	2800	15.1
3	0.016	30	0.161	300	1.61	3000	16.1
3.2	0.017	32	0.172	320	1.72	3200	17.2
3.4	0.018	34	0.183	340	1.83	3400	18.3
3.6	0.019	36	0.194	360	1.94	3600	19.4
3.8	0.020	38	0.205	380	2.05	3800	20.5
4	0.022	40	0.215	400	2.15	4000	21.5
4.2	0.023	42	0.226	420	2.26	4200	22.6
4.4	0.024	44	0.237	440	2.37	4400	23.7
4.6	0.025	46	0.248	460	2.48	4600	24.8
4.8	0.026	48	0.258	480	2.58	4800	25.8
5	0.027	50	0.269	500	2.69	5000	26.9

Wasteload Allocation for Biochemical Oxygen Demand 5-day (kg/day)
2.0

[1] Assumes DIN consists of nitrate. If measured DIN contains ammonia, multiply [ammonia fraction x 1.1] to find equivalent nitrate load.

This wasteload allocation applies from May through October.

All other sources (Bubble allocations including WSDOT stormwater, Empire Disposal stormwater, unpermitted municipal stormwater, tributaries, and other nonpoint)

All other sources and potential sources of dissolved inorganic nitrogen and biochemical oxygen demand are assigned load and wasteload allocations, as applicable. This includes Washington Department of Transportation stormwater, Empire Disposal, all tributaries, unpermitted municipal stormwater discharges, and any other nonpoint sources.

For the majority of the watershed, load and wasteload allocations are being assigned as "bubble allocations." In other words, the total discharge of the pollutant from all combined sources must not exceed the bubble allocation, rather than assigning an individual allocation to each discharging entity or nonpoint source. Table 15 presents the bubble allocations for each 5-km segment.

WSDOT stormwater is included in bubble allocations for many segments where state highways are not located close to the river. In these cases it is not assumed that highway ditches have the potential to discharge directly to the river, but they may discharge to tributaries. In particular, Hwy 272 ditches may discharge to Brush Creek and Clear Creek, and Hwy 27 ditches may discharge to Duffield Creek and Cedar Creek.

These allocations apply during May – November (for DIN) and May – October (for BOD). Limits are not needed outside this time period, as explained previously in the *Loading Capacity* section. If any non-permitted nonpoint source is brought into coverage under an NPDES permit, the appropriate portion of the nonpoint load allocation can be converted to a wasteload allocation.

WSDOT will be considered in compliance with these WLAs by meeting the implementation activities described in this TMDL's Implementation Plan, which will be subsequently incorporated into Appendix 3 of their stormwater permit. Empire Disposal will be considered in compliance with these WLAs by meeting the requirements of their industrial stormwater permit and practices described in this TMDL's Implementation Plan. WSDOT and Empire Disposal must emphasize best management practices and maintenance activities to help ensure runoff does not transport nitrate or ammonia and sediment which may carry these nutrients to their outfalls. If future evaluations determine these practices, coupled with nonpoint source improvements are not adequate to meet the bubble allocations, Ecology may implement adaptive management of this TMDL project, which may require further study and the development of individual wasteload allocations (WLAs).

Table 16. Load or wasteload allocations for WSDOT stormwater, Empire Disposal stormwater, unpermitted municipal stormwater, tributaries, all other nonpoint sources, and bubble allocations.

Upstream end of reach	Downstream end of reach	2012 and draft 2014 303(d) listings primary location[1]	Capacity assignment **Bold = WLA** *Italic = LA*	Allocation for DIN [2] (kg/day)	Allocation for BOD5 (kg/day)
201 km (State line)	196 km (Bridge St. in Palouse)	77904, 70788, 11133, 8112	Bubble[3]: (Includes *general nonpoint* and **DOT stormwater**)	0.010	0.84
196 km	191 km (just abv Duffield Ck.)	70787, 8108	*The entire load capacity for this segment is assigned to Palouse WWTP. (See previous section)*		
191 km	186 km (just abv Cedar Ck.)	70786, 8110	Bubble with Duffield Creek: (*Includes general nonpoint* and **DOT stormwater**)	0.011	0.84
186 km	181 km (~2km blw Altergott Rd.)	77905, 77903, 70785	Bubble with Cedar Creek: (*Includes general nonpoint* and **DOT stormwater**)	0.021	0.84
181 km	176 km (just blw Lange Rd.)	77902, 70784	Bubble: *(Includes general nonpoint* and **DOT stormwater)**	0.017	0.84
176 km	171 km (~2km abv Elberton)	77901, 70783	Bubble: *(Includes general nonpoint* and **DOT stormwater)**	0.021	0.84
171 km	166 km (~3km blw Elberton)	77907, 77906,77900, 70792, 8113	Bubble with Silver Creek: (*Includes general nonpoint* and **DOT stormwater**)	0.020	0.84
166 km	161 km (~4km abv Glenwood)	77900, 8113	Bubble with Brush Creek: (*Includes general nonpoint* and **DOT stormwater**)	0.017	0.84
161 km	156 km (~1km blw Glenwood)	77908, 77899, 70794, 70782	Bubble with Clear Creek: (*Includes general nonpoint* and **DOT stormwater**)	0.014	0.84
156 km	151 km (~2km abv Colfax golf course)	77898,70781	Bubble: (Includes *general nonpoint* and **DOT stormwater)**	0.014	0.84
151 km	146 km (SF Palouse R. confluence)	42553, 42522	Bubble: (Includes general nonpoint, **DOT stormwater,** *Colfax unpermitted stormwater*, and **Empire Disposal**)	0.010	0.84

[1] Since the 5km segmentation differs from the segmentation used for 303(d) development some listings fall in more than one load allocation segment. The listing ID is indicated for the stretch that covers the majority of the listed segment. If the listed segment is fairly evenly within two river stretches it is listed in both.

[2] Assumes DIN consists of nitrate. If measured DIN contains ammonia, multiply [ammonia fraction x 1.1] to find equivalent nitrate load.

[3] Bubble allocations include all sources to that segment of the Palouse River. When a bubble indicates "with a tributary" the allocation is intended for the sum of all sources to the Palouse River and all sources transported through the tributary.

Margin of safety

The water quality standards and policies being implemented by this TMDL project are inherently protective. The load and wasteload allocations established by this TMDL are based on not creating an impact to DO of more than 0.2 mg/L, which is intended to be a negligible impact. The critical flow conditions used to establish these allocations are intended to insure that such an impact would not occur more often than one week every ten years.

In addition, a margin of safety accounts for uncertainty about the pollutant loading and water body response and must be included in all TMDL projects to ensure water quality standards are met, given the uncertainty. In this TMDL report, an implicit margin of safety is being applied by using conservative modeling and analytical assumptions:

- The Wasteload Allocation (WLA) for DIN from Palouse WWTP varies with streamflows in the North Fork Palouse River. This WLA is calculated to insure that DIN from Palouse WWTP will not cause a violation of water quality standards, even when streamflows are less than critical (7Q10) level.
- The WLA for DIN from Palouse WWTP is calculated based only on upstream flows. In reality, the effluent discharge adds a small amount of additional flow that could be taken into account when calculating the dilution capacity of the river.
- The QUAL2Kw model predicts that DO and pH impacts from a discharge equivalent to the loading capacity will dissipate in approximately 1-2 km, however this TMDL only allows discharges to be repeated once every 5 km.

Conclusions and recommendations

- DO and pH in the North Fork Palouse River are very sensitive to dissolved inorganic nitrogen (DIN). Small inputs of DIN can have large impacts to DO and pH.
- The removal of inorganic nitrogen discharged by Palouse WWTP is expected to improve daily minimum DO by up to 4.7 mg/L, and daily maximum pH by up to 0.95 S.U. in the reach downstream of Palouse.
- Wasteload allocations for Palouse WWTP are needed to control dissolved inorganic nitrogen and biochemical oxygen demand between May and October. These wasteload allocations are expected to eliminate the largest negative impacts to DO and pH that are observed in the few miles downstream of the Palouse WWTP outfall.
- Load and wasteload allocations are needed for WSDOT stormwater, Empire Disposal stormwater, unpermitted municipal stormwater, tributaries, and other nonpoint sources. These load and wasteload allocations will prevent DO and pH impairments throughout the North Fork Palouse River.
- The shade produced by system-potential mature riparian vegetation is expected to improve daily minimum DO values by up to 0.8 mg/L, and daily maximum pH values by up to 0.16 S.U. These improvements can be realized through full implementation of the *Palouse River Temperature TMDL* (Snouwaert and Stuart, 2013) and therefore is required comply with the water quality standards for DO and pH.

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Reasonable Assurance

When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint sources) in the water body. For the North Fork Palouse River DO and pH TMDL, both point and nonpoint sources exist. TMDL projects (and related implementation plans) must show "reasonable assurance" that these sources will be reduced to their allocated amount. Education and outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure that the goals of this TMDL project are met.

In most water bodies where Ecology has completed TMDLs for DO, pH, and/or nutrients thus far, nutrient sources add to one another in a compound manner, resulting in a cumulative impact to water quality throughout the system. The North Fork Palouse River is unusual, because it flows so slowly during summer months, each nutrient source creates its own localized impact in the reach immediately downstream of that source. This means that as each source is cleaned up, its immediate downstream impact will be reduced or eliminated as soon as that occurs. For example, Palouse WWTP is the largest single source of inorganic nitrogen in the watershed, producing the largest impacts on DO and pH. Compliance with Palouse WWTP's wasteload allocation will immediately eliminate the largest impacts seen anywhere in the river, and realization of these improvements does not depend on cleaning up any other sources.

That said, all sources need to meet their load and wasteload allocations in order to insure that water quality standards are achieved throughout the system. Ecology believes that the following activities already support this TMDL project and add to the assurance that inorganic nitrogen sources to the North Fork Palouse River will be addressed so the system attains conditions required by Washington State water quality standards. This assumes that the following activities are continued and maintained.

The following rationale helps provide reasonable assurance that the North Fork Palouse River nonpoint source TMDL goals will be met by 2025. The Palouse Conservation District (PCD) actively works with landowners in the watershed to implement practices that reduce runoff and erosion. PCD assists landowners with converting from conventional tillage practices to direct-seed or no-till cropping strategies. PCD and the Natural Resource Conservation Service (NRCS) provide cost-share and technical assistance on implementing riparian buffers, grassed waterways or filter strips, and other agricultural best management practices. Ecology will continue to work with both PCD and NRCS to ensure buffers and other practices implemented are adequate to achieve water quality compliance.

The Whitman County Health Department oversees septic systems, in accordance with Chapter 246-272 WAC, to reduce the potential that they contribute pollutants to the river. The Health Department issues permits for new installations, responds to complaints and reports regarding failing septic systems, and provides education on proper maintenance.

Homes upstream of the city of Palouse, in the “Breeding’s Addition,” utilized on-site septic systems for waste disposal. The depth of soil over rock made it probable that conventional on-site treatment systems would be likely to fail. Therefore, around 2007 the city of Palouse sought to extend its sewer system to this addition to reduce the likelihood of pollution to the river. The construction of the sewer extension was completed in the spring of 2008. As of the publication of this document, five of the 12 homes in the addition have been connected to the sewer system and their septic systems decommissioned. City of Palouse Ordinance No. 839 adopted Palouse Municipal Code §13.46 which requires the remaining seven homes to be connected to the sewer if their on-site septic system is found to be failing, upon sale of the property, or by 2020, whichever is sooner.

Whitman County in cooperation with the cities of Colfax and Palouse are updating their Shoreline Master Program (SMP) in accordance with requirements of Chapter 90.58 RCW. An SMP is a locally-developed set of policies that regulates appropriate shoreline development, promotes public access, and provides environmental protection. At the time this document was drafted it was estimated that the SMP would be completed by summer 2016.

While Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards, it is the goal of all participants in the North Fork Palouse River TMDL process to achieve clean water through cooperative efforts.

Implementation Plan

Introduction

This *implementation plan* was developed by Ecology through collaboration with interested and responsible parties. It describes what will be done to improve water quality. It explains the roles and authorities of cleanup partners (those organizations with jurisdiction, authority, or direct responsibility for cleanup), along with the programs or other means through which they will address these water quality issues. It prioritizes specific actions planned to improve water quality and achieve water quality standards. It expands on the recommendations made as a result of the study described in this report.

With prior TMDL development efforts, Ecology produced an implementation strategy, which was submitted with the technical analysis to the U.S. Environmental Protection Agency (EPA) for TMDL approval as part of the water quality improvement report (WQIR). Then, following EPA's approval, Ecology and interested and responsible parties would develop a water quality implementation plan. However, this section of this water quality improvement report will serve as both the implementation *strategy* and the implementation *plan*.

This implementation plan describes how dissolved inorganic nitrogen levels will be reduced to address dissolved oxygen (DO) and pH impairments to attain water quality standards. The nutrient TMDL reductions should be achieved by 2025 in the North Fork Palouse River.

Who needs to participate in implementation?

As the study outlines, the primary pollutant to control to address the DO and pH impairments is dissolved inorganic nitrogen (DIN). DIN is made up of the nitrate, nitrite, and ammonia forms of nitrogen. The most prominent form in the North Fork Palouse River is nitrate.

The most obvious source of DIN with the largest water quality impact in the North Fork Palouse River is the city of Palouse's wastewater treatment plant. However, nonpoint sources throughout the watershed can have important localized water quality effects where nitrogen enters the river system. This was very apparent during the algal blooms and fish kill during the summer of 2014. Therefore, the city of Palouse is the primary implementation partner for point source reductions, but organizations and landowners will also need to control nonpoint nitrogen sources throughout the watershed through stormwater and land use best management practices.

Besides the city of Palouse, the city of Colfax will need to participate in an investigation of a potential source within their city limits. The Palouse Conservation District and the Natural Resource Conservation Services can provide assistance to landowners throughout the watershed to reduce erosion and runoff that could carry nitrogen to the river or its tributaries. The Whitman County Health Department can assist homeowners correct failing septic systems.

Pollution sources and organizational actions, goals, and schedules

The very apparent DO and pH issues downstream of the WWTP will have to be addressed by the city of Palouse. Those impairments are a result of the effluent only. However, low DO levels and elevated pH levels throughout the rest of the watershed must be improved by nonpoint source reductions. Since the impact of any single source is highly localized to that source, it will be important to address all sources, not just the most obvious point source impact.

Sources of nutrients which contribute to the water quality impairments can be broken into three categories:

1. Instream processes such as nutrients moving from sediments to plants, followed by plant and algae excretion or die-off and decomposition.
2. Continuous sources such as the wastewater treatment plant, failing septic systems, and biosolid and manure applications.
3. Runoff events such as agricultural erosion and runoff from cropland, livestock grazing and feeding areas, drainage through tile drains, and stormwater.

Addressing the continuous and runoff event sources should reduce the productivity in the river, thereby reducing nutrients from instream processes. As the modeling demonstrated, no human-caused inputs of inorganic nitrogen can enter the river for it to achieve natural conditions and meet water quality standards.

Activities to address pollution sources

To achieve water quality standards for DO and pH in the North Fork Palouse River, all anthropogenic sources of inorganic nitrogen will need to be prevented from entering the river system. Additionally, because water temperature affects the amount of oxygen the water can hold and plays an important role in biological and chemical processes, reducing instream temperatures will also be important to achieving water quality standards for DO and pH. The following activities will be necessary to prevent and reduce nitrogen entering the river and to reduce instream temperatures:

- Restoration of full system potential shade on the North Fork of the Palouse River in accordance with the Palouse River Temperature TMDL (Snouwaert & Stuart, 2013).
- Achieving the temperature WLA's from the Palouse River Temperature TMDL (Snouwaert & Stuart, 2013) at the Palouse Wastewater Treatment Plant.
- Incorporation of new dissolved inorganic nitrogen limits into the city of Palouse's NPDES permit for their wastewater treatment plant and compliance with those limits.
- Investigation into a potential source of ammonia and/or nitrate observed downstream of the beginning of the floodworks in Colfax. If a source is found, it must be corrected.
- Prevention of non-stormwater discharges from stormwater outfalls.
- Prevention of anthropogenic sources of nitrogen in stormwater discharges.

- Elimination of effluent from septic systems that are failing near surface water or potentially contaminating groundwater.
- Reduction of livestock impacts to the stream corridor.
- Prevention of runoff from biosolid application sites.
- Prevention of soil erosion and fertilizer mobilization to streams or groundwater from agricultural and residential land.
- Reduction of unnatural stream bank erosion.
- Designing and planning land uses so as to not result in runoff to streams.
- Adhering to state forest practices rules for any timber harvest.

More detail for each of these activities follows.

Restoration of full system potential shade

As the previous section, *System Potential Conditions,* indicates, the pH and DO levels in the North Fork Palouse River are highly sensitive to stream shading. Achieving system potential shade will have a significant impact on whether or not the system can achieve water quality standards for these parameters. Therefore, an essential step for this TMDL project will be to restore riparian vegetation to natural levels. Details about the types and amounts of vegetation that can be supported along the North Fork Palouse River are described in *Palouse River Temperature Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan*. Along the North Fork Palouse River riparian buffers must be 50-75 feet wide and a minimum of 35 feet wide on tributaries to restore system potential shade conditions (Snouwaert & Stuart, 2013).

NPDES Permit Limits and Compliance

The wasteload allocations described in the previous section, *Load and Wasteload Allocations,* will need to be incorporated in the city of Palouse's NPDES permit for their wastewater treatment plant, and then implemented to eliminate the effect the effluent has on DO and pH immediately downstream of the discharge.

The temperature wasteload allocations from the Palouse River Temperature TMDL have been incorporated into the draft city of Palouse's NPDES permit issued in 2014.

WSDOT will be considered in compliance with these WLAs by meeting the implementation activities described in this TMDL's Implementation Plan, which will be subsequently incorporated into Appendix 3 of their stormwater permit. Empire Disposal will be considered in compliance with these WLAs by meeting the requirements of their industrial stormwater permit and practices described in this TMDL's Implementation Plan. When stormwater permits are renewed, they will reflect new TMDL requirements including those in this TMDL.

Investigation of potential source of ammonia and/or nitrate in Colfax

As described in the *Results and Discussion* section under *Nutrients* and *Periphyton and Macrophytes,* there appears to be a source of ammonia or nitrate near or in the North Fork Palouse floodworks in Colfax. Water quality samples taken at stormwater outfalls within the concrete floodworks by a Colfax Senior High School student, with assistance from this report's authors, and a city of Colfax public works employee, confirmed three outfalls are contributing nitrate to the river. However, these three outfalls do not account for the entire nitrate loading observed in this section of river.

Potential sources such as failing septic systems, illicit connections to stormwater sewers, or other discharges to surface or groundwater in the area will need to be investigated. If an unnatural source is located, it will need to be eliminated. Any additional locations within the concrete where water is observed entering the river during dry weather should also be investigated as a potential source.

Prevention of non-stormwater discharges from stormwater outfalls
All stormwater outfalls should be surveyed for signs of discharge during dry weather conditions. If discharges other than stormwater are occurring, the source of this water must be investigated and any illicit sources or connections remedied. If the source is deemed "natural" the water should be tested for nitrate concentrations to determine if it could be having an effect on the river.

Prevention of anthropogenic sources of nitrogen in stormwater discharges
Stormwater can pick up pollutants and carry them to waterways. Best management practices and treatment technologies must be employed to ensure human caused sources of nitrogen are not transmitted through stormwater conveyance systems to streams. Such sources include fertilizer, nitrogen adhered to sediment, animal waste on the ground, and failing septic system effluent. In the North Fork Palouse River watershed the primary stormwater conveyance systems consist of state and county road ditches.

Elimination of effluent from septic systems reaching surface water
Septic systems that are failing to work properly or have a straight-pipe discharge to a ditch, stream, or other area that could flow to the North Fork Palouse River or a tributary can be a source of nutrients affecting DO and pH. Any such systems should be identified and corrected to prevent this pollution source. Depending on the individual circumstances, problem septic systems may need to be repaired, replaced, or if in the vicinity of a public sewer system connected to that system. Opportunities to extend sewers to populated areas should also be considered. Ecology suspects that the city of Palouse's sewer extension to "Breeding's Addition" in 2008 reduced or eliminated a septic system source of effluent to the river.

Reduction of livestock impacts
Livestock can affect the DO and pH of a stream in several ways. Their grazing and trampling of the riparian vegetation can reduce shading needed to achieve natural DO and pH levels. Manure and urine from livestock are also a source of nutrients that can be deposited directly into the stream or on the land surrounding the stream. Precipitation can wash the materials into the streams supplying the nutrients that increase algae and macrophyte productivity that results in the DO and pH problems. Additionally, their hoof action can loosen soil, which often has nutrients associated with it, so it could be transported to the stream with precipitation. A dense healthy buffer of native riparian vegetation between the stream and feeding and grazing activities can prevent these impacts. The 2013 Temperature TMDL for the Palouse River indicated that buffers along the North Fork Palouse River must be 50-75 feet wide and a minimum of 35 feet wide on tributaries to restore system potential shade conditions (Snouwaert & Stuart, 2013).

Prevention of runoff from biosolid application sites

Some wastewater treatment facilities produce biosolids that are then applied to agricultural crops as a nutrient source. Biosolid management is regulated by the Department of Ecology's Waste 2 Resources Program under a general permit, in accordance with Chapter 173-308 WAC. Depending on the site location, a buffer of between 50 and 200 feet is required to protect surface waters from runoff from the site (more information is available at: www.ecy.wa.gov/programs/swfa/biosolids/design.html#surface). Currently the only facility under the biosolids permit with application sites near the North Fork Palouse River is the city of Palouse.

Prevention of soil erosion and fertilizer mobilization

The application of nitrate-based fertilizer is common in agricultural regions like the Palouse watershed. Much of this fertilizer is rapidly taken up by the crops, but any remaining is incorporated into the soil organic matter (Sebilo et.al. 2013). Therefore, erosion from agricultural lands can carry nitrogen attached to sediment into streams. The Palouse River is well known for carrying high sediment loads during spring runoff which can then be deposited in the stream. This sediment could release the nitrogen to the water column and be a source of nutrients for the periphyton and macrophytes affecting the DO and pH of the water.

Soil conservation practices must be implemented on lands with a potential to lose soil to ditches and streams to prevent this source of nitrogen. Practices such as direct seed cropping, grassed waterways, filter strips, cover crops, buffers, and stream bank stabilization projects can significantly reduce erosion so the majority of soil stays on site.

Fertilizer may also leach through the soils to groundwater and then flow subsurface to the river. Sinclair and Kardouni (2009) found elevated nitrate is several groundwater wells in the watershed. Elevated nitrate concentrations in groundwater indicate this is another potential source contributing to the river's DO and pH impairments. It is also a health concern where wells provide drinking water. Best management practices for fertilizer use, such as soil tests and precision application, can contribute to the long-term reduction of nitrate in groundwater.

Reduction of unnatural stream bank erosion

Some stream banks along the North Fork Palouse River are eroding. Often this is a long-term effect of riparian vegetation removal, channel straightening, and land use practices up to the edge of the stream. Sediment from eroding stream banks could carry and deposit nutrients in the stream. Also bank erosion tends to increase the width-to-depth ratio of the channel, which exacerbates the impacts of algae productivity on DO and pH. To reduce this erosion as a possible nutrient source, degraded and eroding stream banks must be restored. Depending on the severity of the erosion these stream bank stabilization projects could range from simple riparian buffer plantings to full scale bank contouring and plantings. The *Integrated Streambank Protection Guidelines* describes many methods for addressing this problem (Washington State Aquatic Habitat Guidelines Program, 2002).

Land use planning and design

Permitting agencies must consider TMDLs during State Environmental Policy Act (SEPA) and other local land use planning reviews. If the land use action under review is known to potentially impact pH and DO as addressed by this TMDL project, then the project may have a significant adverse environmental impact. SEPA lead agencies and reviewers are required to look at potentially significant environmental impacts and alternatives and to document that the necessary environmental analyses have been made. Land-use planners and project managers should consider findings and actions in this TMDL project to help prevent new land uses from violating water quality standards. Ecology published a focus sheet on how TMDLs play a role in SEPA impact analysis, threshold determinations, and mitigation (https://fortress.wa.gov/ecy/publications/SummaryPages/0806008.html). Additionally, the TMDL should be considered in the issuance of land use permits by local authorities.

Forest Practices Rules

The state's forest practices regulations will be relied upon to bring waters into compliance with the load allocations established in this TMDL project on private and state forest lands. This strategy, referred to as the Clean Water Act Assurances, was established as a formal agreement to the 1999 Forests and Fish Report (www.dnr.wa.gov/Publications/fp_rules_forestsandfish.pdf).

The state's forest practices rules were developed with the expectation that the stream buffers and harvest management prescriptions were stringent enough to meet state water quality standards for temperature and turbidity, and provide protection equal to what would be required under a TMDL. As part of the 1999 agreement, new forest practices rules for roads were also established. These new road construction and maintenance standards are intended to provide better control of road-related sediments, provide better stream bank stability protection, and meet current best management practices.

To ensure the rules are as effective as assumed, a formal adaptive management program was established to assess and revise the forest practices rules, as needed. The agreement to rely on the forest practices rules in lieu of developing separate TMDL load allocations or implementation requirements for forestry is conditioned on maintaining an effective adaptive management program.

Consistent with the directives of the 1999 Forests and Fish agreement, Ecology conducted a formal 10-year review of the forest practices and adaptive management programs in 2009: www.ecy.wa.gov/programs/wq/nonpoint/ForestPractices/CWAassurances-FinalRevPaper071509-W97.pdf.

Ecology noted numerous areas where improvements were needed, but also recognized the state's forest practices program provides a substantial framework for bringing the forest practices rules and activities into full compliance with the water quality standards. Therefore, Ecology decided to conditionally extend the CWA assurances with the intent to stimulate the needed improvements. Ecology, in consultation with key stakeholders, established specific milestones for program accomplishment and improvement. These milestones were designed to provide Ecology and the public with confidence that forest practices in the state will be conducted in a manner that does not cause or contribute to a violation of the state water quality standards.

Activity Prioritization

While all sources within the TMDL study area will need to be addressed through various implementation activities, the relative importance of the activities described previously is shown in Table 17.

Table 17. Relative importance of implementation activities.

Highest Importance	Medium Importance	Lower Importance
NPDES Permit limits and compliance	Livestock impacts	Forest and Fish Practices
Investigate and correction of potential source near Colfax	Reduction of septic system effluent	Land use planning
Prevention of soil erosion and fertilizer mobilization	Reduction of stream bank erosion	
Restoration of system potential shade	Prevention of non-stormwater discharges from stormwater outfalls	Runoff prevention from biosolid application sites
Prevention of anthropogenic sources of nitrogen in stormwater discharges		

Organizations' actions, goals, and schedules

City of Colfax

The city of Colfax (City) must participate in locating the source of the nitrate discharging within the city limits to the concrete floodworks. Various pipes outfall to the channel and at least two stormwater outfalls have been observed discharging water during dry weather. One is located along Hwy 195 near the 6th Street Bridge. The other is near 5th Street on the left river bank.

For the Hwy 195 stormwater outfall, the City should partner with the Washington State Department of Transportation (WSDOT) and Ecology to determine the source of the water. This partnership is recommended because the highway's ditches may be a contributing source to the outfall.

The investigation of the 5th Street outfall should include a search for possible cross-connections between the sanitary sewer and the storm sewer.

If any other unpermitted non-stormwater or non-groundwater discharges to the river are discovered the City must eliminate them.

City of Palouse

The city of Palouse has three areas of focus to implement nutrient reductions for this TMDL project. These include reductions at the wastewater treatment plant (WWTP), possible non-stormwater discharges through the stormwater system, and runoff from the biosolids application site.

The most significant reductions will be required at the WWTP. The wasteload allocations listed earlier in this report will be incorporated into the facility's next NPDES permit. In anticipation of this TMDL project, the current permit requires a facility plan in 2017 examining options to meet the dissolved inorganic nitrogen wasteload allocations. The current permit also includes steps to come into compliance with the temperature wasteload allocations from the Temperature TMDL.

The city of Palouse must also investigate any stormwater outfalls that discharge during dry weather. One such outfall observed by Ecology exists under the Bridge Street Bridge. Non-stormwater discharges could carry pollutants to the river if they are the result of an illicit connection or unauthorized disposal. If such sources are found they must be remedied.

The WWTP's biosolids must be applied according to their biosolids permit to avoid any runoff or groundwater impacts that affect the river.

Empire Disposal

To comply with the WLAs in this TMDL, Empire Disposal must meet the requirements of the Industrial Stormwater permit. Empire Disposal must emphasize best management practices and maintenance activities to ensure runoff does not transport nitrate, ammonia, or sediment which may carry these nutrients to their outfalls. Since such small quantities of DIN and BOD can be discharged into the river, elimination of critical season discharges may be the most effective means for achieving the WLA.

Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) administers several programs including the Environmental Quality Incentives Program (EQIP), which provides technical and financial assistance to agricultural producers. These programs focus on implementing best management practices to conserve natural resources, including protecting water quality. Practices that reduce and prevent runoff and erosion to the stream are crucial to the success of this TMDL project. When the goal of the best management practices to be implemented is to address a potential water quality concern or identified issue, NRCS will confer with Ecology to ensure the practices are adequate to address the problem. NRCS will continue to offer these programs for the Palouse River as long as funding continues.

Palouse-Clearwater Environmental Institute

The Palouse-Clearwater Environmental Institute (PCEI) is a community-based non-profit organization that serves the Palouse region. PCEI promotes the conservation, preservation, and restoration of environmentally sensitive lands, natural areas, and unique ecosystems through education and implementation of restoration projects. PCEI has 20 years of stream restoration experience, completing more than 85 watershed restoration projects, totaling more than 22 miles of stream and 70 acres of riparian buffer restored to a natural, functional state. The work has encompassed stream re-meanders, bank stabilization and erosion control, installation of bioengineering structures, and tree/shrub planting. This also includes the creation of 55 wetlands covering 3.2 acres. Projects are collaborative in nature and are always science-based and community-centered. PCEI will actively seek opportunities to work on riparian restoration projects and community education throughout the TMDL project area.

Palouse Conservation District

The majority of the North Fork Palouse River watershed is within the Palouse Conservation District (PCD). PCD is a non-regulatory organization that assists land managers with implementing conservation practices. PCD provides technical and financial assistance to landowners to implement practices that reduce or prevent runoff and erosion. Many of these practices protect water quality including reducing the amount of nitrate reaching streams. PCD also worked with landowners to restore riparian areas along the North Fork Palouse River and its tributaries and will continue to do so. Restored riparian areas will help buffer streams from land uses and provide shade to reduce instream temperatures, which is a key component of achieving water quality standards for DO and pH.

To assist landowners toward this TMDL project's nitrate reduction goals, PCD will promote direct seed technology and assist landowners with the implementation of agricultural best management practices through existing and future funding and technical assistance programs. PCD is currently working with landowners to convert a minimum of 800 acres of agricultural land from conventional tillage to direct seed by 2018. PCD also has technical and financial assistance available to assist livestock producers with projects that prevent erosion and runoff from livestock operations. Examples of projects they can assist with include corrals, livestock exclusion fencing, off-stream watering, heavy use areas, and manure management.

To assist toward this TMDL project's goal to restore system potential shade, PCD will continue to maintain the previously planted areas while funding exists, after which the responsibility for maintenance will fall to the landowner. PCD will also use existing and future funding programs to assist landowners with restoring and enhancing riparian buffers throughout the watershed. Currently PCD is assisting landowners with stabilizing stream banks so the riparian areas can be enrolled in the Whitman County Conservation Reserve Enhancement Pilot Program (CREP).

When a landowner seeks PCD assistance to correct an identified water quality problem, PCD will confer with Ecology to ensure implemented practices are sufficient to protect water quality and address the potential for pollution delivery.

Palouse Land Trust

The Palouse Land Trust is a 501 (c)(3) non-profit organization that helps landowners conserve the open space, scenery, wildlife habitat, and water quality of the Palouse region. The Palouse Land Trust works with willing landowners to establish conservation easements that protect and conserve working lands and wildlife habitat. These easements can provide income and tax incentives to the landowner. In response to this TMDL project, the Palouse Land Trust will increase efforts to work with landowners to establish conservation easements along the North Fork Palouse River and its tributaries. While the goal of conservation easements is not exclusively to address water quality, easements are consistent with these purposes. The Palouse Land Trust encourages landowners to work with partners like the Conservation Districts to enroll in other programs and implement practices that are protective and address pollution issues. The Palouse Land Trust will seek assistance from Ecology when a landowner is interested in making water quality improvements.

The Planning Departments of Whitman County, City of Colfax, and City of Palouse

Planning Departments, Commissions, or designees for the municipalities in the study area will consider the findings and requirements of this TMDL for land use decisions. The TMDL report provides some of the best available science for determining if a land use action has a potential to be detrimental to the stream environment and water quality. Land use reviews will ensure activities are carried out in a manner consistent with this and other TMDLs for the Palouse River.

Whitman County, city of Colfax, and city of Palouse will update their Shoreline Master Programs (SMP) in 2016. SMPs are local land use policies and regulations designed to manage shoreline use. These programs are required by the Shoreline Management Act to protect natural shoreline resources, provide for public access to water and shores, and plan for water-dependent land uses. While most on-going agriculture activities are exempt from the SMP, requirements for new land uses and shoreline development under the updated SMP are expected to be consistent with those found in this and other TMDLs within the SMP jurisdictional areas.

Residents and landowners

Streams in Washington are considered waters of the state and belong to all citizens of the state; therefore, it is everyone's responsibility to protect the health of these systems for current uses and future generations. Nitrate can come from many different nonpoint sources of pollution. Some of these sources include:

- Sediment from erosion.
- Fertilizers.
- Nutrients in domestic animal waste.
- Septic system seepage to groundwater or overland flow from failing systems.

Residents and landowners can ensure nitrate from their land does not impact streams by installing best management practices to reduce runoff from their property. One of the best tools for reducing and filtering runoff are riparian buffers. These buffers slow runoff, which increases infiltration and allows sediment (which may carry nitrate) to settle out. The riparian vegetation also helps towards the goal of achieving system potential shade.

Buffers help prevent fertilizers from running off to streams. However, residents should also take care to apply fertilizers away from streams and away from slopes that could wash off to streams with precipitation. Fertilizers must be applied in accordance with manufacturer's instructions (e.g., application rate, timing) to reduce the potential for pollution.

Animal waste is another source of nitrate. Animals should be managed to prevent their waste from reaching waterways. Fencing animals away from streams and drainages, building adequate waste storage facilities, and installing heavy use protection are some practices that can reduce the potential for waste to enter a waterway. Since nitrate can also leach into groundwater and then travel to streams animals should also be managed to ensure their wastes are not contributing to groundwater contamination.

Failing or improperly designed septic systems are another residential source of nitrate. Homeowners are required by WAC 246-272A-0270 to have their systems inspected at least once every three years. Regular inspection and maintenance is vital to extending the life of a septic system. If a homeowner suspects their septic system may not be functioning properly, they should contact the Whitman County Health Department for evaluation and assistance.

Many of the agencies and organizations in this plan can provide technical and/or financial assistance for the implementation of these practices.

Washington State Department of Ecology

The Department of Ecology (Ecology) will oversee and track the progress made toward meeting the TMDL load and wasteload allocations and the implementation of activities in this implementation plan. If the streams are not on track to meet water quality targets, the TMDL coordinator will apply adaptive management (see section later in this document).

As the agency that regulates wastewater treatment plants and Washington State Department of Transportation's stormwater from state highways and facilities, Ecology will ensure requirements to implement the TMDL are incorporated into the respective NPDES permits.

Ecology will provide funding, through its competitive water quality grant and loan funding cycle, to projects that address the goals of this plan and rank high enough to receive funding. Additional points are awarded during the application evaluation for projects implementing TMDLs. The Ecology TMDL lead will provide feedback on grant applications, prior to their submission, to help applicants refine their scope of work to develop the best project that has the highest likelihood of being funded.

Ecology will refer nonpoint sources of pollution to the appropriate entity, such as a conservation district, to receive technical and financial assistance to correct the pollution problem. If necessary, Ecology will use its authority under Revised Code of Washington (RCW) 90.48 to enforce water quality regulations.

Washington State Department of Transportation (WSDOT)

Three WSDOT highways (27, 195, and 272) traverse the North Fork Palouse River DO and pH TMDL boundary (see Figure 1). While Ecology did not directly measure WSDOT stormwater outfalls during the TMDL study, it is assumed stormwater from adjacent properties conveyed through WSDOT facilities is a source of nitrogen to waterways. Therefore, certain actions by WSDOT are required under this TMDL project and will be incorporated into their NPDES stormwater permit.

WSDOT's stormwater permit will not be renewed until 2019. At that time implementation requirements from this TMDL project will be incorporated into the renewed permit. However, in recognition of the importance of addressing these issues and currently having the resources available, WSDOT will begin some implementation prior to permit requirements. Ecology is very appreciative of WSDOT's commitment and commends them for taking this initiative and going beyond the norm. This is an unusual circumstance and should not be expected elsewhere. Table 18 describes the activities WSDOT will initiate prior to permit requirements. This table will only be in effect until the permit is renewed. It is also understood that if WSDOT's resource situation changes during this interim period, WSDOT may have to step back on early implementation until this TMDL is added to their permit.

The following paragraphs describe the implementation activities that will be incorporated into the stormwater permit once it is renewed in 2019. Many of these activities are similar to or the same as some which will be implemented early, so these descriptions can also be used to better understand the early implementation actions. Table 19 outlines those items which will be incorporated into the renewed permit.

WSDOT will implement the Highway Runoff Manual (HRM) within the TMDL boundary.

Table 18 WSDOT Early Implementation Actions (expires when permit is renewed and is subject to resource availability).

Activity	Timeline
Implement the Highway Runoff Manual.	Initiate when the TMDL is approved and ongoing.
Minimize potential nitrogen impacts from hydro-seed and chemical treatments.	Initiate when the TMDL is approved and ongoing.
Correct and report confirmed illicit discharges to Ecology through the Environmental Report Tracking System (ERTS).	Initiate when the TMDL is approved and ongoing.
Provide Ecology with a map of *known sediment problem areas. The information provided will prioritize the most problematic locations.	Provide map within one year of TMDL approval. Update map annually as needed if new problem areas are identified (ongoing).
Implement coordinated State Highway Sediment Delivery Prevention Strategy with Ecology.	Initiate January 2016 and ongoing.

*Known sediment problem areas are locations where runoff from adjacent land enters a WSDOT conveyance and deposits sediment that triggers frequent to continual sediment removal activity by our maintenance staff. The mapping and prioritization activity is not a complete inventory of all sediment problem areas in the watershed. Conditions that cause sediment problem areas are dynamic and vary seasonally; therefore what constitutes a "sediment problem area" is at the discretion of the maintenance staff that perform the sediment removal work. Due to the variable field conditions, WSDOT needs a year to compile the first map in order to perform due diligence in accurately identifying known sediment problem areas.

If stormwater discharges that transport nitrogen over natural background levels to listed receiving waters are found from sources within WSDOT's right-of-way, WSDOT will apply best management practices (BMPs) from their Stormwater Pollution Prevention Plan (SWMPP) or perform remediation to correct discharges. For run-on sources of nitrogen identified by WSDOT that are from outside of WSDOT's right-of-way, WSDOT will notify Ecology and work cooperatively with Ecology, the local jurisdiction, and other parties involved for their resolution.

To address nitrogen delivery associated with adjacent erosion (run-on sources), WSDOT will work to prevent sediment from entering area waterways along highway right-of-ways. WSDOT will compile and prioritize known sediment problem areas and submit a map of these locations to Ecology. The map will be based on ditch cleanout and maintenance records and a GIS exercise to locate potential run-on issues. WSDOT will work with Ecology to prevent sediment from entering area waterways via WSDOT's stormwater system by implementing the *State Highway Sediment Delivery Prevention Strategy*. WSDOT has partnered with Ecology on this coordinated strategy to address sediment loading to ditches and other stormwater conveyances, which is being piloted in the Hangman Creek TMDL boundary area. This is a draft strategy which may evolve as it is implemented. This effort will be on-going as part of standard inspection and maintenance and periodic surveys with Ecology. The initial problem area map and prioritization will be updated annually.

To address non-sediment associated nitrogen sources from adjacent land uses transported through WSDOT stormwater conveyances, WSDOT will record these sources in their Illicit Discharge Detection and Elimination (IDDE) database and report them to the Environmental Report Tracking System (ERTS). To address these sources WSDOT will notify Ecology through ERTS and work cooperatively with Ecology, the local jurisdiction, and other parties involved for their resolution. An annual query of the IDDE database will be provided to Ecology's TMDL Lead.

WSDOT must minimize potential impacts to waterways from hydro-seed and chemical treatments that include forms of nitrogen. In addition to best management practices to prevent contamination during application, transport during future storms and runoff should be considered.

Within the cities of Palouse and Colfax, WSDOT allocates maintenance responsibilities between WSDOT and the city according to a memorandum of understanding (MOU) signed with the Association of Washington Cities. A right bank stormwater outfall to Colfax's concrete floodworks near 6^{th} Street is known to discharge during dry weather. This outfall likely includes runoff and ditch conveyance from Highway 195. An unofficial screening study by a Colfax High School student showed nitrate present in the water. WSDOT and the city of Colfax should partner on the investigation into the source of this continuous discharge and its nitrate load.

If at the time of permit renewal, significant progress has not been made on addressing nutrients sources transported through WSDOT's stormwater conveyances by implementing early actions, WSDOT will implement the Programmatic Approach from Appendix 3 of their permit, and relevant portions of the stormwater management program plan (SWMPP) on WSDOT highways and facilities within this TMDL boundary. Significant progress will be defined collaboratively between Ecology and WSDOT if and when this adaptive management needs to be applied.

Implementation of the Programmatic Approach includes a WSDOT inventory of highway discharge locations to assess them for the potential to contribute sediment or nitrogen to the Palouse River or any of its named or unnamed tributaries or drainages. The inventory of unnamed tributaries and drainages may be limited to those that are visually identifiable as conveying water continuously for more than one month of the year. Potential nitrogen sources flowing through WSDOT ditches and other conveyances could include agricultural field runoff, failing or straight pipe septic systems, livestock runoff, and general erosion. The priority of the inventory efforts should be in the following order:

- Hwy 272 through the city of Palouse and Hwy 27 along the North Fork Palouse River.
- Hwy 195 north of Colfax along the North Fork Palouse River including runoff to the stormwater outfall near 6^{th} Street.
- Hwy 272 discharges to named and unnamed tributaries of the North Fork Palouse.

Table 19 WSDOT Implementation Actions for Inclusion in Renewed Stormwater Permit.

Activity	Timeline
Implement Highway Runoff Manual within TMDL boundary	Initiate when TMDL is added to WSDOT's permit and ongoing
Correct and report confirmed illicit discharges to Ecology through the Environmental Report Tracking System (ERTS)	Initiate when TMDL is added to WSDOT's permit and ongoing
Provide Ecology with a map of known sediment problem areas. Information provided will include a prioritization ranking of the worst locations.	Within 1 year of the TMDL being added to WSDOT's permit and updated annually as needed if new areas are identified
Implement coordinated State Highway Sediment Delivery Prevention Strategy with Ecology	Initiate when TMDL is added to WSDOT's permit and ongoing
Minimize potential nitrogen impacts from hydro-seed and chemical treatments within TMDL boundary	Initiate when TMDL is added to WSDOT's permit and ongoing
Implement the Programmatic Approach inventory	If determined appropriate after the TMDL has been added to WSDOT's permit

Washington State Department of Natural Resources and Forest Practitioners

The Washington Department of Natural Resources (WDNR) will implement the Clean Water Act Assurances forest practice regulations, including the additional milestones specified in the 2009 assessment for these regulations. Buffers and best management practices must be implemented in accordance with these regulations and specifically in the North Fork Palouse River watershed they must be adequate to ensure no nitrogen-carrying water or sediment enters any waterway.

Whitman Conservation District

A small portion of the North Fork Palouse River is within Whitman Conservation District (WCD). This entire portion is within the city of Colfax's city limits. WCD is a non-regulatory organization that assists land managers with implementing conservation practices. WCD provides technical and financial assistance to landowners to restore riparian areas and protect water quality.

Whitman County Health Department

The 2007 Washington Legislature strengthened the legal statutes (WAC 246-272A) regulating on-site septic systems (OSS). Whitman County Health Department adopted the state code and has made substantial progress on implementing these requirements. In 2014 the County approved the Health Department's development of a county operation and maintenance plan (O & M) which will guide development and management activities for all OSS in Whitman County.

The Health Department's O & M plan, which will be completed by summer 2015, will outline homeowner responsibilities, describe educational materials that will be developed for owners of septic systems, require companies that pump septic tanks to submit their pump reports to the Health Department, and detail the Health Department's tracking of existing and new septic systems.

All new permits issued for septic systems require the owner of the system to follow an O & M plan in accordance with WAC 246-272A-0270 which includes regular inspection at least every 3 years and pumping of the system when inspection reveal solids and scum levels indicate pumping is necessary.

Newly constructed OSS are tagged and tracked on a geographic information system (GIS) map within the Health Department's tracking database. The database will include schedules for mailing reminders to owners for maintenance, inspection, and pumping. The Health Department is also initiating a program to locate and map systems installed prior to permitting requirements.

Failing septic systems are required by law to be repaired or replaced. If a system is within 250 feet of a sewer line it must be connected to the sewer line and the historic septic system decommissioned. To assist residents with the costs of repairs, replacements, and connections the Health Department will direct homeowner to existing funding programs and may seek additional funding for a county-wide assistance program.

Whitman County Public Works Engineering and Road Bridge Maintenance Divisions
The county will use various best management and maintenance practices in an attempt to prevent and reduce the amount of nitrogen-contaminated water entering their stormwater conveyance systems and discharging to streams and drainages within county controlled areas. Sources of nitrogen that may enter their stormwater conveyances include runoff and erosion from adjacent properties, failing septic system discharges, and vegetation maintenance activities (such as pruning, mowing, and hydro-seeding) which could deposit vegetation or other nitrogen sources in the ditches. If specific sites are a reoccurring or persistent source of sediment to county ditches, the county will confer with Ecology to determine potential methods to address the issue on a site-specific basis. Suspected failing septic system discharges will be reported to Whitman County Health.

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Measuring Progress toward Goals

A monitoring program for evaluating progress is an important component of any implementation plan. Monitoring is needed to keep track of what activities have been done, measure the success or failure of actions, and evaluate if water quality standards are achieved. Monitoring should continue after water quality standards are obtained to ensure implementation measures are effective and standards continue to be met.

Each entity involved in implementation should monitor and track the results of their efforts. Entities with enforcement authority will be responsible for following up on any enforcement actions. NPDES permittees will need to track progress with coming into compliance with the requirements of their permits. Those conducting restoration projects or installing BMPs will be responsible for monitoring plant survival rates and maintenance of improvements, structures, and fencing.

Ecology will monitor the progress of implementation and resulting instream water quality conditions. Ecology will use this information to make sure the Palouse River is on track for meeting the DO and pH water quality standards. As demonstrated in the modeling discussion in this report, compliance with the water quality standards will most likely depend on meeting the river's natural conditions rather than the numeric criteria. Assuming all implementation is achieved in a timely manner the Palouse River should meet water quality standards for DO and pH by 2025.

Performance measures and targets

The activities listed in this implementation plan need to be tracked to determine:

- What activities were performed and where.
- Whether the actions worked and could be applied elsewhere.
- What practices should be considered for adaptive management, if necessary.
- If resources or some other factor are preventing some actions from occurring.
- Whether this implementation plan is adequate to meet water quality standards.

Ecology's TMDL coordinator will work with the organizations outlined in this document to track implementation activities occurring in the watershed. Depending on Ecology's resources and current implementation tracking tools, the coordinator will either use an Excel© spreadsheet, Ecology's TMDL management database or geographic information system (GIS) mapping to track where implementation has occurred or is planned.

Each organization should track the implementation progress they have made.

Effectiveness monitoring plan

Effectiveness monitoring determines if the interim targets and water quality standards have been met after the measures described in the water quality implementation plan are functioning (i.e. the instream water quality monitoring). Effectiveness monitoring of TMDL projects is usually conducted by the Environmental Assessment Program.

A quality assurance project plan (QAPP) should be prepared before any water quality monitoring is conducted by Ecology or others. The QAPP should follow Ecology guidelines (Lombard and Kirchmer, 2004), paying particular attention to consistency in sampling and analytical methods. The Ecology TMDL coordinator will recommend monitoring schedules and locations based on this report and completed implementation. At a minimum the sites in Table 20 should be included in any future effectiveness monitoring.

Table 20. Sites recommended for effectiveness monitoring.

Site	Reasoning
34PAL120.3 (at Palouse) (aka 34A170)	Long term station; upstream of Palouse WWTP, near state line; confirm unexplained 2007 around-the-clock high pH above town has been addressed
34PALWTP (Palouse WWTP)	Determine compliance with WLAs
34PAL118.9	To determine the impact of changes at the WWTP
34PAL116.8	Assess changes of pH constriction
34PAL91.7	Determine background for comparison with 34PAL91.5
34PAL91.5 (above confluence with South Fork Palouse)	Compare with background at 34PAL91.7 to determine if sources within concrete channel have been remedied

Effectiveness monitoring should take place after significant implementation has been completed. Milestones which may warrant effectiveness monitoring include Palouse WWTP plant upgrades and modifications, as well as any significant nonpoint source implementation. Monitoring should take place during the critical period of May – October. The parameters that should be included in any effectiveness monitoring should include:

- Continuous DO
- Continuous pH
- Continuous temperature
- Total nitrogen
- Nitrate-nitrite nitrogen
- Ammonia nitrogen

Ideally, total phosphorus and orthophosphate would also be included in this effectiveness monitoring.

The coordinator will use the results of monitoring by Ecology and others to determine if this plan is working as written. If sufficient progress is not made, the coordinator will begin adaptive management (discussed in the *Adaptive Management* section).

Adaptive management

Natural systems are complex and dynamic. The way a system will respond to human management activities is often unknown and can only be described as probabilities or possibilities. Adaptive management involves testing, monitoring, evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings. In the case of TMDL projects, Ecology uses adaptive management to assess whether the actions identified as necessary to solve the identified pollution problems are the correct ones and whether they are working. As we implement these actions, the system will respond, and it will also change. Adaptive management allows us to fine-tune our actions to make them more effective, and to try new strategies if we have evidence that a new approach could help us to achieve compliance.

Partners will work together to monitor progress towards these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the implementation strategy as needed. TMDL reductions should be achieved by 2025. However, if water quality standards are achieved, but wasteload and load allocations are not, the TMDL project will be considered satisfied.

Ecology will use adaptive management when water monitoring data show that the TMDL project targets are not being met or implementation activities are not producing the desired result. A feedback loop (Figure 23) consisting of the following steps will be implemented:

Step 1. The activities in the water quality implementation plan are put into practice.

Step 2. Programs and best management practices (BMPs) are evaluated for technical adequacy of design and installation.

Step 3. The effectiveness of the activities is evaluated by assessing new monitoring data and comparing it to the data used to set the TMDL project targets.

- Step 3a. If the goals and objectives are achieved, the implementation efforts are adequate as designed, installed, and maintained. Project success and accomplishments should be publicized and reported to continue project implementation and increase public support.

- Step 3b. If not, then BMPs and the implementation plan will be modified or new actions identified. The new or modified activities are then applied as in Step 1.

It is ultimately Ecology's responsibility to assure that implementation is being actively pursued and water standards are achieved.

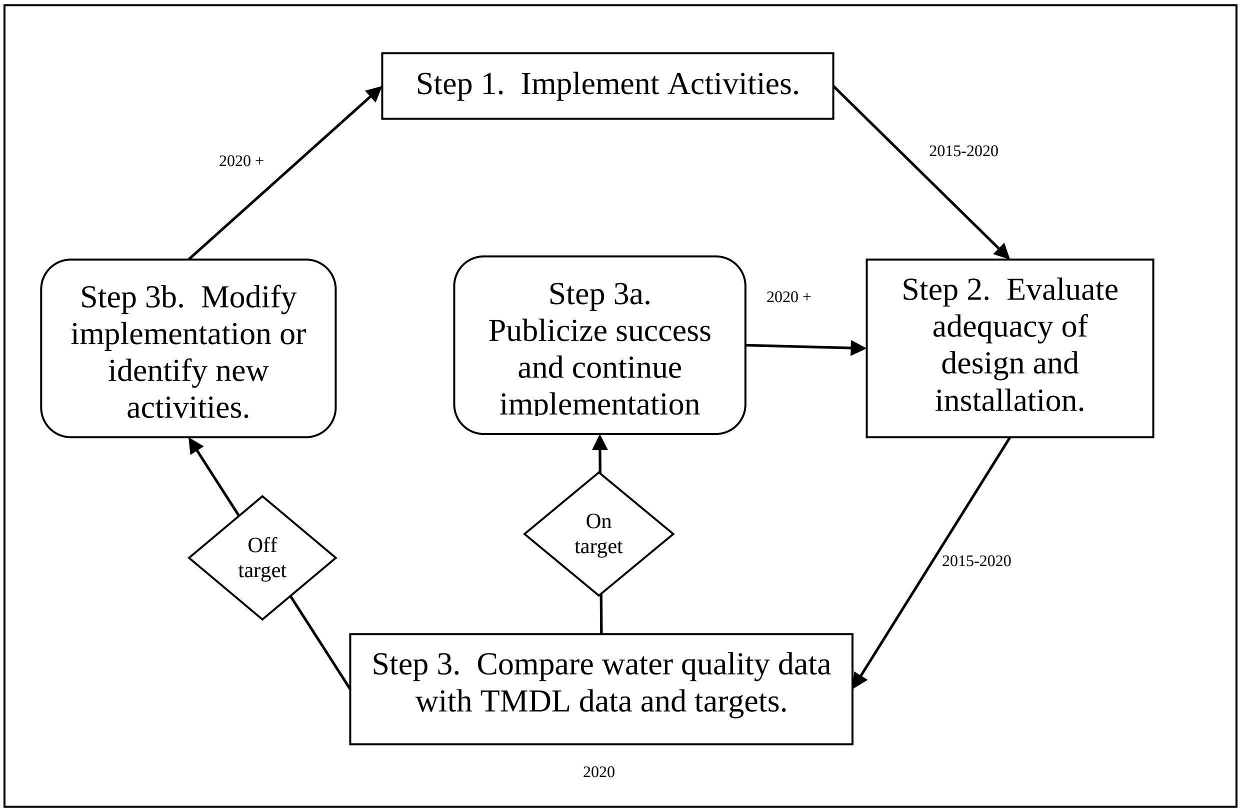

Figure 23. Feedback loop for determining need for adaptive management.

Dates are estimates and may change depending on resources and implementation status.

Funding Opportunities

Multiple sources of financial assistance for water quality improvement activities are available through Ecology's grant and loan programs, local conservation districts, and other sources. Refer to the website (www.ecy.wa.gov/programs/wq/tmdl/TMDLFunding.html) for a list and descriptions of funding sources.

Ecology's Centennial Clean Water Fund, Section 319, and State Water Pollution Control Revolving Fund grants and loans can provide funding to help implement this TMDL. In addition to Ecology's funding programs, there are many other funding sources available for watershed planning and implementation, point and nonpoint source pollution management, fish and wildlife habitat enhancement, stream restoration, and water quality education. Public sources of funding include federal and state government programs, which can offer financial as well as technical assistance. Private sources of funding include private foundations, which most often fund nonprofit organizations with tax-exempt status. Forming partnerships with other government agencies, nonprofit organizations, and private businesses can often be the most effective approach to maximize funding opportunities. Some of the most commonly accessed funding source for TMDL implementation efforts are shown in Table 21 and are described following the table.

Table 21. Potential funding sources for implementation projects.

Fund Source	Type of Project Funded	Maximum Amounts
Centennial Clean Water Fund	Watershed planning, stream restoration, & water pollution control projects.	$500,000
Palouse River Watershed (WRIA 34) Implementation Partnership	Conversion to direct seed cropping management, riparian buffers, conservation easements, etc.	Dependent on practices implemented
Section 319 Nonpoint Source Fund	Nonpoint source control; i.e., pet waste, stormwater runoff, & agriculture, etc.	$500,000
State Water Pollution Control Revolving Fund	Low-interest loans to upgrade pollution control facilities to address nonpoint source problems; failing septic systems.	10% of total SRF annually
Conservation Reserve Program (CRP)	Establishes long-term conservation cover of grasses, trees and shrubs on eligible land.	Rental payments based on the value of the land; plus 50% - 90% cost share dependent on practices implemented
Environmental Quality Incentives Program (EQIP)	Natural resource protection.	Dependent on practices implemented
Wildlife Habitat Incentive Program (WHIP)	Provide funds to enhance and protect wildlife habitat including water.	$25,000 dependent on practices implemented
Agricultural Conservation Easement Program (ACEP)	Financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits.	Dependent on appraised land value

Centennial Clean Water Fund (CCWF)
A 1986 state statute created the Water Quality Account, which includes the Centennial Clean Water Fund (CCWF). Ecology offers CCWF grants and loans to local governments, tribes, and other public entities for water pollution control projects. The application process is the same for CCWF, 319 Nonpoint Source Fund, and the State Water Pollution Control Revolving Fund.

Palouse River Watershed (WRIA 34) Implementation Partnership
USDA's Natural Resources Conservation Service (NRCS) awarded the Palouse River Watershed (WRIA 34) Implementation Partnership, through their Regional Conservation Partnership Program (RCPP), $5.5 million improve water quality, soil health, and habitat in the Palouse River Watershed. This funding will complement the $5.5 million in significant contributions from the regional partnership to direct a total of $11 million to innovative conservation projects in the Palouse River Watershed during the 2015 to 2020 timeframe. A portion of these funds may go to projects within the North Fork Palouse River TMDL boundary.

This partnership has the following goals for implementation in the larger Palouse River watershed over the program's five year timeframe:

- Minimize soil erosion on farm fields by working with operators to enroll over 50,000 acres in conservation tillage designed to reduce soil erosion by up to 95%.

- Establish approximately 300 acres of native trees and shrubs along approximately 35 miles of streams and rivers to act as a buffer to reduce sedimentation, lower water temperatures and filter out pollutants. In addition to improving water quality, these projects are expected to benefit fish and wildlife habitat, including four fish species of concern that are listed under the Endangered Species Act.

- Prevent the conversion of working farmlands to non-agriculture uses on 520 acres of prime farmland through permanent conservation easements.

More information about this unique funding program is available at www.palousecd.org/#!rcpp/c1d4e.

Section 319 Nonpoint Source Fund
The 319 Fund provides grants to local governments, tribes, state agencies and nonprofit organizations to address nonpoint source pollution to improve and protect water quality. These organizations can apply to Ecology during the annual combined funding cycle for funding through a 319 grant to provide additional implementation assistance.

State Water Pollution Control Revolving Fund
Ecology also administers the Washington State Water Pollution Control Revolving Fund. This program uses federal funding from U.S. Environmental Protection Agency and monies appropriated from the state's Water Quality Account to provide low-interest loans to local governments, tribes, and other public entities. The loans are primarily for upgrading or expanding water pollution control facilities, such as public wastewater and stormwater plants, and for activities to address nonpoint source water quality problems.

Conservation Reserve Program (CRP)
The CRP is a voluntary program for agricultural landowners. Through CRP, landowners can receive annual rental payments and cost-share assistance to establish long-term, resource conserving vegetative or vegetation covers on eligible farmland. Included under CRP is the Continuous Conservation Reserve Program (CCRP), which provides funds for special practices for both upland and riparian land. Landowners can enroll in CCRP at any time. There are designated sign up periods for CRP.

The Commodity Credit Corporation (CCC) makes annual rental payments based on the agriculture rental value of the land, and it provides cost-share assistance for 50 to 90 percent of the participant's costs in establishing approved conservation practices. Participants enroll in CRP contracts for 10 to 15 years.

The program is administered by the CCC through the Farm Service Agency (FSA), and program support is provided by Natural Resources Conservation Service, Cooperative State Research and Education Extension Service, state forestry agencies, and local conservation districts.

Environmental Quality Incentives Program (EQIP)
The federally funded Environmental Quality Incentives Program (EQIP) is administered by NRCS. EQIP is the combination of several conservation programs that address soil, water, and related natural resource concerns. EQIP encourages environmental enhancements on land in an environmentally beneficial and cost-effective manner. The EQIP program:

- Provides technical assistance, cost share, and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm.
- Has 75 percent cost-share, but allows 90 percent if the producer is a limited resource or beginning farmer.
- Has contracts lasting five to ten years.
- Has no annual payment limitation; sum not to exceed $450,000 per farm.

Wildlife Habitat Incentive Program (WHIP)
WHIP is administered by NRCS and is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land. Through WHIP, NRCS provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP agreements between NRCS and the participant generally last from five to ten years from the date the agreement is signed.

Agricultural Conservation Easement Program (ACEP)
ACEP is a federal funding program administered by NRCS that consists of two components: Agricultural Land Easements and Wetland Reserve Easements. Agricultural Land Easements protect the long-term viability of the nation's food supply by preventing conversion of productive working lands to non-agricultural uses. Land protected by agricultural land easements provides additional public benefits, including environmental quality, historic preservation, wildlife habitat and protection of open space.

Wetland Reserve Easements provide habitat for fish and wildlife, including threatened and endangered species, improve water quality by filtering sediments and chemicals, reduce flooding, recharge groundwater, protect biological diversity and provide opportunities for educational, scientific and limited recreational activities.

Summary of Public Involvement

Planning for this and other Palouse River watershed TMDLs began in 2005. At this time and for several years after, the Palouse Watershed Planning Unit, established under Chapter 90.82 of the Revised Code of Washington (RCW), met regularly to plan, discuss, and develop management plans for watershed issues. Ecology staff regularly attended these monthly meetings and presented information on the TMDLs underway and scheduled.

Prior to starting the study and data collection for the temperature TMDL, Ecology held a public meeting on April 25, 2007 in Colfax, Washington. This meeting was publicized via direct mailings to the Palouse Watershed TMDL mailing list, a news release, and advertisements in area newspapers. Approximately 12-15 people attended the meeting with 10 signing in. Information was presented about the Clean Water Act requirement to develop TMDLs for the Palouse River and specifics about the study design.

Several letters including updates on the status of the project were sent to the Palouse Watershed TMDL mailing list during the course of its development.

Several meetings were held between Ecology and the city of Palouse during the spring of 2014 to discuss this TMDL's implications for operation of the city's WWTP. Ecology presented information about this TMDL project, the effect the WWTP is having on the river, and the potential impact to the WWTP's permit.

Organizations outlined as having a role in implementing this TMDL were invited to review and provide input on the implementation plan during its development.

A public meeting to present this TMDL was held in the city of Palouse on August 3, 2015. A 30-day public comment period was held on this TMDL and implementation plan from July 22 to August 21, 2015. A press release to local media and advertisements in the Moscow-Pullman Daily News and Whitman Gazette newspapers announced the public comment period. These papers, the Lewiston Tribune, and KQQQ radio also produced stories regarding this project. Five sets of comments were received. Ecology's response to these comments and any resulting changes in the TMDL are described in Appendix F.

Information about this TMDL has been available on the *Palouse River – Water Quality Improvement Project Website* since the start of project:
www.ecy.wa.gov/programs/wq/tmdl/palouse/palouse_mainstem.html

References

Ahmed, 2004. North Fork Palouse River Fecal Coliform Bacteria Total Maximum Daily Load Recommendations. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/SummaryPages/0403022.html

APHA, 2005. Standard Methods for the Analysis of Water and Wastewater, 21st Edition. Joint publication of the American Public Health Association, American Water Works Association, and Water Environment Federation. www.standardmethods.org/.

ASTM, 1997. Standard test methods for determining sediment concentration in water samples (ASTM Designation: D-3977-97). American Society for Testing and Materials, West Conshohocken, PA.

Banta, G., M. Pedersen, and S. Nielsen, 2004. Decomposition of marine primary producers: consequences for nutrient recycling and retention in coastal ecosystems. In Nielsen, S., G.

Banta, and M. Pedersen, 2004. Estuarine Nutrient Cycling: The Influence of Primary Producers. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Barko, J., D. Gunnison, and S. Carpenter, 1991. Sediment interactions with submersed macrophyte growth and community dynamics. Aquatic Botany, 41:41-65.

Berger, C., 2000. Modeling Macrophytes of the Columbia Slough. PhD dissertation. Portland State University, Portland, OR.

Biggs, B., 1996. Patterns in Benthic Algae of Streams. In Stevenson, R., M. Bothwell, and R. Lowe, 1996. Algal Ecology: Freshwater Benthic Ecosystems. Academic Press, San Diego, CA.

Borchardt, M., 1996. Nutrients. In Stevenson, R., M. Bothwell, and R. Lowe, 1996. Algal Ecology: Freshwater Benthic Ecosystems. Academic Press, San Diego, CA.

Bothwell, M., 1985. Phosphorus limitation of lotic periphyton growth rates: An intersite comparison using continuous-flow troughs (Thompson River system, British Columbia). Limnology and Oceanography 30:527-542.

Bothwell, M., 1989. Phosphorus-limited growth dynamics of lotic periphyton diatom communities: areal biomass and cellular growth rate responses. Canadian Journal of Fisheries and Aquatic Sciences 46:1293-1301.

Carroll, J., 2007. Quality Assurance Project Plan: Palouse River DO and pH Total Maximum Daily Load Study-Water Quality Study Design. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-110. https://fortress.wa.gov/ecy/publications/SummaryPages/0703110.html

Carroll, J., 2012. Addendum to Quality Assurance Project Plan: Palouse River Dissolved Oxygen and pH Total Maximum Daily Load – Water Quality Study Design. Washington State Department of Ecology, Olympia, WA. Publication No. 12-03-121. https://fortress.wa.gov/ecy/publications/SummaryPages/1203121.html

Carroll, J. and N. Mathieu, 2006. Quality Assurance Project Plan: South Fork Palouse River Dissolved Oxygen and pH Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-112 https://fortress.wa.gov/ecy/publications/SummaryPages/0603112.html

Carroll, J., and E. Snouwaert, 2009. South Fork Palouse River Fecal Coliform Bacteria TMDL: Water Quality Improvement Report. Washington State Department of Ecology, Olympia, WA. Publication No. 09-10-060. https://fortress.wa.gov/ecy/publications/SummaryPages/0910060.html

Chapra, S.C., 1997. Surface Water-Quality Modeling. McGraw-Hill Companies, Inc.

Charles, K.J., N.J. Ashbolt, D.J. Roser, R. McGuinness, and D.A. Deere, 2005. Effluent quality from 200 on-site sewage systems: design values for guidelines. Water Science and Technology 15:163-169.

Cusimano, B., 2003. Data Summary: Spokane River and Lake Spokane (Long Lake) Pollutant Loading Assessment for Protecting Dissolved Oxygen. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-023. https://fortress.wa.gov/ecy/publications/SummaryPages/0303023.html

Ecology, 2006 (Revised January 2012). Water Quality Standards for the Surface Waters of the State of Washington, Chapter 173-201A WAC. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/SummaryPages/0610091.html

Ecology, 2008. TTools for ArcGIS. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/models.html

Gilmore, S., 2004. Palouse Subbasin Management Plan. Resource Planning Unlimited, Inc. Moscow, ID. Prepared for Palouse-Rock Lake Conservation District, St. John, WA. www.nwcouncil.org/fw/subbasinplanning/palouse/plan/Plan.pdf

Hallock, D. and W. Ehinger, 2003. Quality Assurance Monitoring Plan: Stream Ambient Water Quality Monitoring, Revision of 1995 Version. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-200. https://fortress.wa.gov/ecy/publications/summarypages/0303200.html

Henderson, R., 2005. Palouse River Tributaries Subbasin Assessment and TMDL. Idaho Department of Environmental Quality, Boise, ID. www.deq.idaho.gov/water-quality/surface-water/tmdls/table-of-sbas-tmdls/palouse-river-tributaries-subbasin.aspx

Johnson, A., B. Era-Miller, and K. Kinney, 2007. Palouse River Chlorinated Pesticide and PCB Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-018. https://fortress.wa.gov/ecy/publications/summarypages/0703018.html

Joy, J., G. Pelletier, and K. Baldwin, 2007. Walla Walla River Basin pH and Dissolved Oxygen Total Maximum Daily Load Study: Water Quality Improvement Report. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-010. https://fortress.wa.gov/ecy/publications/SummaryPages/0703010.html

Kardouni, J., J. Carroll, and K. Sinclair, 2007. Quality Assurance Project Plan: Palouse River Temperature Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-106. https://fortress.wa.gov/ecy/publications/summarypages/0703106.html

Kendra, W., 1988. Quality of Palouse Wastewater Treatment Plant Effluent and Impact of Discharge to the North Fork Palouse River. Washington State Department of Ecology, Olympia, WA. Publication No. 88-e25. https://fortress.wa.gov/ecy/publications/summarypages/88e25.html

Mathieu, N., J. Carroll, and B. Nipp, 2007. Quality Assurance Project Plan: Palouse River Bacteria Total Maximum Daily Load Water Quality Study Design. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-108. https://fortress.wa.gov/ecy/publications/SummaryPages/0703108.html

Menzel, D. and J. Ryther, 1964. The composition of particulate organic matter in the western North Atlantic. Limnology and Oceanography, 9:179-186.

Monod, J. 1950. La technique de culture continue, théorie et applications. Ann. Inst. Pasteur, Paris, 79:390-410.

Mulholland, P., 1996. Role of Nutrient Cycling in Streams. In Stevenson, R., M. Bothwell, and R. Lowe, 1996. Algal Ecology: Freshwater Benthic Ecosystems. Academic Press, San Diego, CA.

Pelletier, G. and S. Chapra, 2008. QUAL2Kw: a modeling framework for simulating river and stream water quality. User's Manual, Theory and documentation. www.ecy.wa.gov/programs/eap/models.html

Porter, S.D., T.F. Cuffney, M.E. Gurtz, and M.R. Meador, 1993. Methods for Collecting Algal Samples as Part of the National Water-Quality Assessment Program; U.S. Geological Survey, Open-File Report 93-409, Denver, CO.

Sebilo, M., B. Mayer, B. Nicolardot, G. Pinay, and A. Mariotti, 2013. Long-term fate of nitrate fertilizer in agricultural soils. PNAS Early Edition. http://www.pnas.org/content/110/45/18185.full?sid=f9f04682-cfda-4178-95b4-e16dd88d1b76

Sinclair, K. and Kardouni, J., 2009. Surface-water/Groundwater Interactions and Near-stream Groundwater Quality along the Palouse River, South Fork Palouse River, and Paradise Creek. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-007. https://fortress.wa.gov/ecy/publications/SummaryPages/0903007.html

Snouwaert, E., and A. Ahmed, 2005. North Fork Palouse River Fecal Coliform Total Maximum Daily Load: Submittal Report. Washington State Department of Ecology, Olympia, WA. Publication No. 04-10-067. https://fortress.wa.gov/ecy/publications/SummaryPages/0410067.html

Snouwaert, E., and T. Stuart, 2013. Palouse Temperature Total Maximum Daily Load: Water Quality Improvement Report and Implementation Plan. Washington State Department of Ecology, Olympia, WA. Publication No. 13-10-020. https://fortress.wa.gov/ecy/publications/SummaryPages/1310020.html

Tarbutton, S., J. Carroll, and E. Snouwaert, 2010. Palouse River Fecal Coliform Bacteria TMDL: Water Quality Improvement Report and Implementation Plan. Washington State Department of Ecology, Olympia, WA. Publication No. 10-10-067. https://fortress.wa.gov/ecy/publications/SummaryPages/1010067.html

Washington State Aquatic Habitat Guidelines Program, 2002. Integrated Streambank Protection Guidelines. Washington Department of Fish and Wildlife, Washington State Department of Transportation, Washington State Department of Ecology, Olympia, WA. http://wdfw.wa.gov/publications/00046/

Welch, E.B. and J.M. Jacoby, 2004. Pollutant Effects in Freshwater, Applied Limnology, Third Edition, Spon Press, New York, NY.

Whitman County Gazette, 2014a. N. Palouse Turns Green: DOE Orders Water Lab Tests. Whitman County Gazette, July 30, 2014, Colfax, WA.

Whitman County Gazette, 2014b. City Buries Dead Fish From River. Whitman County Gazette, August 21, 2014, Colfax, WA.

Withers, P.J.A., H.P. Jarvie, and C. Stoate, 2011. Quantifying the impact of septic tank systems on eutrophication risk in rural headwaters. Environment International, 37:644-653

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Appendices

Appendix A – Appendix D

These appendices are published separately and are available at
https://fortress.wa.gov/ecy/publications/parts/1510029part1.pdf

Appendix A.: Data Summary
Appendix B.: Data Quality
Appendix C.: QUAL2Kw Model Inputs and Calibration
Appendix D.: Breeding's Addition model scenario

Appendix E. Glossary, Acronyms, and Abbreviations

Glossary

303(d) List: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited water bodies (ocean waters, estuaries, lakes, and streams) that fall short of state surface water quality standards and are not expected to improve within the next two years.

Analyte: Water quality constituent being measured (parameter).

Areal: Measured with respect to area. For example, periphyton and macrophyte biomass are typically expressed areally, in units such as mg/m^2.

Best management practices (BMPs): Physical, structural, or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Biochemical oxygen demand (BOD): The depletion of dissolved oxygen from the water when organic matter is oxidized by microorganisms.

Bubble allocation: A location-based allocation which covers loading from all sources within a specific geographic area. A bubble allocation is shared among all contributing sources.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 (see definition) flow event unless determined otherwise by the department.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved inorganic nitrogen (DIN): Ammonia + nitrate + nitrite.

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (for example, diurnal temperature rises during the day and falls during the night.)

Ecosystem respiration (ER): The total respiration, or conversion of organic compounds to carbon dioxide, that occurs in the stream. ER is typically expressed in terms of the oxygen that is consumed. It can be expressed volumetrically ($mgO_2/L/day$) or areally ($gO_2/m^2/day$).

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Exceeded criteria: Did not meet criteria.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Gross Primary Production (GPP): The total conversion of carbon dioxide to organic compounds through photosynthesis that occurs in the stream. GPP is typically expressed in terms of the oxygen that is produced. It can be expressed volumetrically ($mgO_2/L/day$) or areally ($gO_2/m^2/day$).

Inorganic: Inorganic nutrients are contained in small, simple molecules and are readily taken up by periphyton and macrophytes.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Macrophytes: Aquatic plants that grow in or near water and are either emergent, submergent, or floating.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing and revising permits, as well as imposing and enforcing pretreatment requirements, under the Clean Water Act. The NPDES permit program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Natural conditions: Surface water quality that was present before any human-caused pollution. Also called "natural background levels."

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to, atmospheric deposition; surface water runoff from agricultural lands; urban areas; or forest lands; subsurface or underground sources; or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Organic: Organic nutrients are nutrients that are contained in complex organic molecules, and which are not readily available for uptake by periphyton or macrophytes.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Periphyton: A complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that are attached to submerged surfaces in most aquatic ecosystems.

Photosynthetic Quotient (PQ): The moles of oxygen produced by photosynthesis divided by the moles of carbon dioxide assimilated.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Plume: Describes the three-dimensional concentration of particles in the water column (example, a cloud of sediment).

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than five acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Reach: A specific portion or segment of a stream.

Reaeration: Gas exchange between the water and the atmosphere.

Remineralization: The conversion, by hydrolysis, of organic nutrients to inorganic nutrients.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Sensitivity Analysis: An analysis of a numerical model to determine which inputs and/or rate parameters have a large effect on model outputs, and which ones do not.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces, such as lawns, pastures, and playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Surrogate measures: To provide more meaningful and measurable pollutant loading targets, EPA regulations [40 CFR 130.2(i)] allow other appropriate measures, or surrogate measures in a TMDL. The Report of the Federal Advisory Committee on the Total Maximum Daily Load

(TMDL) Program (EPA, 1998) includes the following guidance on the use of surrogate measures for TMDL development:

When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not.

System potential: The design condition used for TMDL analysis.

S**ystem-potential mature riparian vegetation:** Vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

System-potential temperature: An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system-potential condition uses best estimates of *mature riparian vegetation, system potential channel morphology, and system-potential riparian microclimate* that would occur absent any human alteration.

Total maximum daily load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Total suspended solids (TSS): The suspended particulate matter in a water sample as retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

7Q2 flow: A typical low-flow condition. The 7Q2 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every other year on average. The 7Q2 flow is commonly used to represent the average low-flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q2 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

7Q10 flow: A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every 10 years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10 percent of the data exists and below which 90 percent of the data exists.

Acronyms and abbreviations

A	chlorophyll *a*
AFDW	ash-free dry weight
BMP	best management practice
BOD	biochemical oxygen demand
BOD5	5-day biochemical oxygen demand test
C	carbon
CBOD	carbonaceous biochemical oxygen demand
CO_2	carbon dioxide
CWA	Clean Water Act
D	dry weight
DIN	dissolved inorganic nitrogen
DL	detection limit
DO	dissolved oxygen
DOC	dissolved organic carbon
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management (Ecology's environmental database)
EPA	U.S. Environmental Protection Agency
ER	ecosystem respiration
GIS	Geographic Information System software
GPP	gross primary production
HCO_3^-	bicarbonate
IDEQ	Idaho Department of Environmental Quality
N	Nitrogen
NF	North Fork
NH_4	Ammonia (abbreviated as NH_4 rather than NH_3 because usually in ionized form)
NO_2	Nitrite
NO_3	Nitrate
NPDES	National Pollutant Discharge Elimination System
O_2	Oxygen
OP	orthophosphate (this abbreviation is *not* used to refer to organic phosphorus)
P	Phosphorus
POC	particulate organic carbon
POTW	publicly owned treatment works
PQ	photosynthetic quotient

RM	river mile
RMA	River Metabolism Analyzer tool
RMSE	root mean squared error
RMSE CV	root mean squared error coefficient of variation
RSD	relative standard deviation
SF	South Fork
SOP	standard operating procedure
SRP	soluble reactive phosphorus
TMDL	total maximum daily load (water cleanup plan)
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TNVSS	total non-volatile suspended solids
TOC	total organic carbon
TP	total phosphorus
TPN	total persulfate nitrogen
TSS	total suspended solids
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
WQA	Water Quality Assessment
WQIR	water quality improvement report
WSDOT	Washington State Department of Transportation
WWTP	wastewater treatment plant

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cms	cubic meters per second, a unit of flow.
dw	dry weight
/d	portion per day
°F	degrees Fahrenheit
ft	feet
ft/s	feet per second
g	gram, a unit of mass
g/m^2	grams per square meter
$gO_2/m^2/day$	grams of oxygen per square meter per day, a unit of primary production or respiration.
kg	kilograms, a unit of mass equal to 1,000 grams.
kg/d	kilograms per day
km	kilometer, a unit of length equal to 1,000 meters.
km^2	square kilometer
m	meter
m/d	meters per day
m/s	meters per second
mi	mile

mi^2	square mile
mg/L	milligrams per liter (parts per million)
mg/m^2	milligrams per square meter
moles/L	moles per liter
NTU	nephelometric turbidity units
ppm	parts per million
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
uS/cm	microsiemens per centimeter, a unit of conductivity

Appendix F. Response to Public Comments

A 30-day public comment period was held on this TMDL and implementation plan from July 22 to August 21, 2015. A press release to local media and advertisements in the Moscow-Pullman Daily News and Whitman Gazette newspapers announced the public comment period. These papers, the Lewiston Tribune, and KQQQ radio also produced stories regarding this project. Five sets of comments were received. The comments and Ecology's response, including any resulting changes in this report, are described here.

Comments from Thomas C. Lamar, Executive Director, Palouse-Clearwater Environmental Institute (PCEI)

PCEI is very interested in helping to restore our waterways of eastern Washington and northern Idaho. We are actively engaged in restoration activities throughout the area. In fact, we have been working with the city of Potlatch to implement (well, first secure funding, and then implementing...) a restoration project on the North Fork. We would be very much interested in working with your office, or other offices on similar restoration activities on the Washington side of the border.

Ecology's Response:

Thank you for your comments. Due to PCEI's interest in working in the North Fork Palouse River watershed, a section describing your organization and potential activities has been added to the implementation plan.

Comments from Walter Steed, Council Member, City of Moscow

Wanted to make sure you were aware that the City of Potlatch, Idaho, has, since the summer of 2013, been land applying in order to reduce the volume of outflow from their wastewater treatment plant into the Palouse River.

Since your Report last appears to have data from 2012, I thought their change might be helpful to the North Fork and to your future data collection.

Ecology's Response:

Thank you for this information. Our study found that the pollutant of concern, dissolved inorganic nitrogen, was undetectable at the state line. Land application would reduce the levels in the river. Therefore, Potlatch's treatment change should not have any effect on the reductions needed in Washington.

Comments from David Lange, Landowner and Resident

Project is largely pointed at agriculture and comment period is during harvest....Really

Areas of concern:
- municipalities contribution
- low river flows (trying to make a pristine river out of a creek)

Ecology's Response:

Thank you for your comments. While agriculture is one of many possible sources, the report is clear that the biggest impact on dissolved oxygen and pH levels in the river is from the City of Palouse's wastewater treatment plant's discharge. The second paragraph of the section titled "What needs to be done in this watershed?" in the Executive Summary states "The most obvious source of [dissolved inorganic nitrogen] with the largest water quality impact in the North Fork Palouse River is the city of Palouse's Wastewater Treatment Plan (WWTP)." For this reason Ecology did not anticipate much input from the agricultural community on this plan and therefore, did not believe the timing of our comment period would be a concern. Had we received a request to extend the comment period, we would have likely granted it.

Limitations on the contributions from municipal wastewater are addressed in the section titled Load and Wasteload Allocations. Additionally municipal stormwater is also described.

The analysis within this report takes into consideration the natural flow levels of the river. These flows would be very low during the critical period even historically. Therefore, the implementation plan does not call for increasing flow other than what may occur incidentally due to other river restoration efforts. For example, increasing shade may reduce evaporation or increasing direct seed may increase infiltration that could help sustain flows through groundwater movement over a longer period.

Comments from William C. Steward, Environmental Protection Specialist, Environmental Protection Agency - Region 10

Thank you for the opportunity to comment on the draft *North Fork Palouse River Dissolved Oxygen and pH Total Maximum Daily Load*. The document is well written and well organized.

General Comments:

1. In looking at Figure ES-2 on page xv, the severe cyanobacteria bloom has to be related to excess nutrients in this reach of the river. While it is understood that modeling seems to indicate nitrogen as the limiting nutrient it would appear that phosphorus isn't lacking in this bloom. Strictly speaking, I am not so sure that only paying attention to inorganic nitrogen is the best path.

2. One thing to note is that while some nitrogen in a stream can be lost to the atmosphere, the same is not true for phosphorus in water. Looking at the sample data from the Palouse WWTP it appears that high concentrations of TP and OP as well as nitrogen are present. The phosphorus in the WWTP discharge appears to be mostly dissolved orthophosphorus and therefore highly available for plant growth.

3. Rather than use a DIN to OP ratio to determine a limiting nutrient, was consideration given to the effects of addressing reductions of both nitrogen and phosphorus in the model?

4. Why was the decision made to use total persulfate nitrogen used instead of total kjeldahl nitrogen as shown in table A-4? I don't believe TPN is an approved EPA method for analysis?

5. Some cyanobacteria are capable of fixing atmospheric nitrogen for growth. Was this considered in the modeling efforts?

6. In general, the concentrations of nutrients in the water seem quite low for the amount of vegetation produced in the river. Was there any attempt to look at nutrient concentrations in the bottom substrate of the river?

7. It seems likely that since DIN and OP are highly available to plant growth that these nutrients are rapidly taken up by the luxuriant growth in the river and that is why concentrations appear to be low in the water column. Plant respiration (and decomposition?) combine during night time to reduce the DO in the water.

Again, thank you for the opportunity to review this TMDL and I look forward to seeing the final version of this document. I would be happy to discuss this project with you at your convenience.

Ecology's Response:

Thank you for your comments. Each is addressed below:

1. It is true that phosphorus levels in the river are high relative to nitrogen. Due to the excess phosphorus the nutrient that needs to be reduced to limit periphyton growth is nitrogen. However, all the point source and nonpoint source activities called for in this TMDL will also reduce phosphorus.

2. The wasteload allocations in this TMDL require extremely low DIN levels in the Palouse WWTP discharge which will likely be achieved by removing the effluent discharge during the critical period. Doing so would also remove the phosphorus loading.

3. Sensitivity analysis scenarios using the QUAL2Kw model indicate that reducing only phosphorus, without reducing nitrogen, would have little effect on DO and pH. However, reducing only nitrogen, without reducing phosphorus, would have a substantial effect. Reducing both nitrogen and phosphorus would have essentially the same effect as reducing nitrogen only. This is because the supply rate of phosphorus, relative to demand, is greater than for nitrogen. This information is found in the technical appendices in Appendix C, subheading "Sensitivity Analysis Scenarios," Figure C-6. Nitrogen was identified as the limiting nutrient using multiple lines of evidence. This TMDL focuses on

nitrogen reductions for simplicity's sake, understanding that in the real world, nutrient reduction activities will actually reduce both nitrogen and phosphorus.

4. Ecology's Manchester Lab favors total persulfate nitrogen (TPN) over total kjeldahl nitrogen (TKN) for two reasons. First, TPN is a single analysis that provides a measure of total nitrogen (TPN = TN) whereas TKN measures ammonia nitrogen + organic nitrogen, but does not include nitrate-nitrite nitrogen. This means that if you are using TKN, total nitrogen must be calculated as TN = TKN + NO2-3. Second, TPN is a simpler and more cost-effective lab procedure than TKN.

5. The cyanobacteria bloom that occurred in the summer of 2014 is not a typical occurrence. This TMDL is written to address the long-term periphyton productivity problem in the river rather than an isolated cyanobacteria bloom. Therefore, the model analysis did not include the ability of cyanobacteria to fix nitrogen. The cyanobacteria bloom was described to demonstrate some of the consequences of excess nutrients in the river.

6. The data collected for this study did not include streambed sediment nutrients. However we agree with your comment. In fact, in order to use the model to successfully explain the high amount of algae productivity given the low levels of nutrients present, it was necessary to account for nutrient movement from the substrate into the water column. This was done by modeling macrophyte growth, respiration, death, and decay.

7. We agree.

Comments from Mike Petersen, Executive Director, The Lands Council

The Lands Council would like to respond to the draft plan for the North Fork Palouse River, which aims to improve water quality and stream health for fish and other aquatic life. The high pH indicates that water is alkaline, which can result in toxic or lethal conditions for aquatic life. One pollutant this plan addresses is nitrogen, which acts like a fertilizer, causing algae to flourish.

The most significant, concentrated source of nitrogen to the North Fork Palouse River is discharge from the City of Palouse wastewater treatment plant. The city will need to explore options to meet new permit limits required by this plan.

Other actions needed to achieve water quality standards are listed, and we support the specific goals of reducing non-point sources of nutrients and increasing vegetative cover as outlined in the draft plan:

- Restoring the historic natural levels of streamside shade.

  The pH and DO levels in the North Fork Palouse River are highly sensitive to stream shading. Achieving system potential shade will have a significant impact on whether or not the system can achieve water quality standards for these parameters. Therefore, an essential step for this TMDL project will be to restore riparian vegetation to natural levels. Details about the types and amounts of vegetation that can be supported along the North Fork Palouse River are described in Palouse River Temperature Total Maximum Daily Load Water Quality Improvement Report and

Implementation Plan. Along the North Fork Palouse River riparian buffers must be 50-75 feet wide and a minimum of 35 feet wide

- Reducing pollution in stormwater runoff.

  Septic systems that are failing to work properly or have a straight-pipe discharge to a ditch, stream, or other area that could flow to the North Fork Palouse River or a tributary can be a source of nutrients affecting DO and pH. Any such systems should be identified and corrected to prevent this pollution source. Depending on the individual circumstances, problem septic systems may need to be repaired, replaced, or if in the vicinity of a public sewer system connected to that system. Opportunities to extend sewers to populated areas should also be considered.

- Preventing soil erosion and fertilizer nutrient release to streams or groundwater from agricultural and residential land.

  The application of nitrate-based fertilizer is common in agricultural regions like the Palouse watershed. Much of this fertilizer is rapidly taken up by the crops, but any remaining, is incorporated into the soil organic matter (Sebilo et.al. 2013). Therefore, erosion from agricultural lands can carry nitrogen attached to sediment into streams. The Palouse River is well known for carrying high sediment loads during spring runoff which can then be deposited in the stream. This sediment could release the nitrogen to the water column and be a source of nutrients for the periphyton and macrophytes affecting the DO and pH of the water.

  Soil conservation practices must be implemented on lands with a potential to lose soil to ditches and streams to prevent this source of nitrogen. Practices such as direct seed cropping, grassed waterways, filter strips, cover crops, buffers, and stream bank stabilization projects can significantly reduce erosion so the majority of soil stays on site.

  Fertilizer may also leach through the soils to groundwater and then flow subsurface to the river. Sinclair and Kardouni (2009) found elevated nitrate is several groundwater wells in the watershed. Elevated nitrate concentrations in groundwater indicate this is another potential source contributing to the river's DO and pH impairments. It is also a health concern where wells provide drinking water. Best management practices for fertilizer use, such as soil tests and precision application, can contribute to the long-term reduction of nitrate in groundwater.

  Some stream banks along the North Fork Palouse River are eroding. Often this is a long-term effect of riparian vegetation removal, channel straightening, and land use practices up to the edge of the stream. Sediment from eroding stream banks could carry and deposit nutrients in the stream. Also bank erosion tends to increase the width-to-depth ratio of the channel, which exacerbates the impacts of algae productivity on DO and pH. To reduce this erosion as a possible nutrient source, degraded and eroding stream banks must be restored. Depending on the severity of the erosion these stream bank stabilization projects could range from simple riparian buffer plantings to full scale bank contouring and plantings. The Integrated

Streambank Protection Guidelines describes many methods for addressing this problem (Washington State Aquatic Habitat Guidelines Program, 2002).

- Stopping failing septic systems effluent from reaching the river.

We appreciate that Ecology has identified the problems and sources of non-point sources of pollution and has identified general practices that would mitigate the problems, such as stream bank plantings, riparian buffers, fixing or removing failing septic systems and restoring streambanks. Ecology has also identified sources of funding, partners and other resources. What is missing is an implementation plan that shows where and when these improvements in water quality and dissolved oxygen levels will occur.

Landowners are likely aware that riparian buffers and cattle exclusion would improve water quality, but the question is whether this will actually occur. How many buffers are actually planned, how many direct seed operations will occur, and how will this relate to improved water quality? Forest landowners are required to have stream buffers associated with their activities, when will this occur on farm and ranch lands? Shading is known to lower water temperatures, but what are the targets and goals for increased shading. What are the costs associated with these streamside improvements and how does that link to available funding resources?

We wish you luck with the restoration of the North Fork Palouse River and hope that our comments are helpful.

Ecology's Response:

Thank you for your comments. Unfortunately it is very difficult to lay out a specific schedule for when the necessary nonpoint source implementation will occur. This difficulty exists because the planning for these activities requires working with each individual landowner who may seek one of our partners' assistance to develop their individual plan, schedule, and financial assistance. However, one of our partners, the Palouse Conservation District, has funding and technical assistance available through the Regional Conservation Partnership Program (RCPP) which has specific implementation goals over the 5 years of implementation. While this RCPP funding program is for the whole Palouse River watershed, not just the North Fork Palouse River, it is likely some of these goals will be achieved within the TMDL boundary. A description of this funding source has been added to the Implementation Plan. Additional information, regarding projects the Palouse Conservation District has planned within the North Fork Palouse River watershed, has also been added to their section in the Implementation Plan.